PB89-136634

Regulatory Impact Analysis of the Proposed Regulations for Sewage Sludge Use and Disposal

Eastern Research Group, Inc., Arlington, MA

Prepared for

Environmental Protection Agency, Washington, DC

18 Jan 89

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO.

2.

3. Recipient's Accession No.
PB89-136634/AS

4. Title and Subtitle
Regulatory Impact Analysis of the Proposed Regulations for Sewage Sludge Use and Disposal

5. Report Date
January 18, 1989

6.

7. Author(s)
U.S. Environmental Protection Agency

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Water Regulations and Standards
401 M Street S.W.
Washington, D.C. 20460

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report evaluates the economic impacts of proposed regulations pertaining to the use and disposal of sewage sludge generated by publicly owned treatment works. The analysis also evaluates the impacts associated with three other regulatory options, each reflecting a different set of regulatory requirements and varying levels of stringency. Six conventional sludge use and disposal practices are addressed in the report: (1) landfilling, (2) incineration, (3) ocean disposal, (4) surface disposal, (5) distribution and marketing, and (6) land application. The report provides a profile of the wastewater treatment industry, an analysis of the costs associated with complying with the proposed regulation and the three other regulatory options, a case study analysis to assess the impacts of pretreatment as it pertains to the proposed regulation, a summary of the baseline health risks of sludge use and disposal, and an estimate of the benefits (expressed as the reduction in health risks) asssociated with the proposed regulation.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
To be made available to the public

19. Security Class (This Report)

20. Security Class (This Page)

21. No. of Pages
462

22. Price
A20

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

PB89-136634

REGULATORY IMPACT ANALYSIS
OF THE PROPOSED REGULATIONS FOR
SEWAGE SLUDGE USE AND DISPOSAL

Prepared for:

Robert Esworthy
Debra Nicoll

Office of Water
Economic Analysis Branch
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Prepared by:

Anne Jones
Lynn Knight
David Meyers

Eastern Research Group, Inc.
6 Whittemore Street
Arlington, MA 02174

January 18, 1989

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

TABLE OF CONTENTS

Page

SECTION ONE EXECUTIVE SUMMARY

1.1 The Regulatory Options 1-1
1.2 Number and Type of Treatment Plants 1-3
1.3 Costs and Benefits 1-5

1.3.1 Option 1 1-7
1.3.2 Option 2 1-10
1.3.3 Option 3 1-14
1.3.4 Option 4 1-18

1.4 Effect of Pretreatment on Sludge Quality 1-20

SECTION TWO INTRODUCTION 2-1

2.1 Scope 2-1

2.2 Organization 2-2

2.3 Data Sources 2-2

SECTION THREE PROFILE OF SLUDGE GENERATION, TREATMENT, USE, AND DISPOSAL 3-1

3.1 Wastewater Treatment 3-4

3.1.1 Pretreatment 3-4
3.1.2 Preliminary Treatment 3-8
3.1.3 Primary Treatment 3-8
3.1.4 Secondary Treatment 3-10
3.1.5 Advanced Treatment 3-12
3.1.6 No Discharge 3-13

3.2 Sludge Treatment 3-13

3.2.1 Sludge Conditioning 3-14
3.2.2 Thickening 3-14
3.2.3 Stabilization 3-15
3.2.4 Dewatering 3-16

3.3 Sludge Use and Disposal 3-17

3.3.1 Incineration 3-19
3.3.2 Ocean Disposal 3-19
3.3.3 Surface Impoundments 3-19
3.3.4 Landfilling 3-20
3.3.5 Land Application and Distribution and Marketing 3-22

TABLE OF CONTENTS (continued)

Page

3.4 National Distribution of Sludge Use and Disposal Methods 3-24

3.4.1 Incineration 3-24
3.4.2 Ocean Disposal 3-33
3.4.3 Distribution and Marketing 3-37
3.4.4 Land Application and Landfilling 3-43
3.4.5 Distribution of Sludge Volume by Disposal Method 3-57

3.5 Sludge Characteristics 3-58

3.5.1 Overview of the Major Constituents in Wastewater Sludge 3-60
3.5.2 Typical Levels of Selected Contaminants in Sludge 3-64
3.5.3 Potential Implications of the National Pre-Treatment Program on Future Contaminant Levels in Sludge 3-66

3.6 Economic Profile of POTWs 3-73

3.6.1 Overview of POTWs 3-74
3.6.2 Capital Costs 3-76
3.6.3 Operating and Maintenance Costs 3-79
3.6.4 Sludge Disposal Costs 3-80
3.6.5 Revenue Requirements 3-89

3.7 Existing Regulations Regarding the Disposal and Use of Municipal Wastewater Sludge 3-93

3.7.1 Incineration 3-93
3.7.2 Ocean Disposal 3-97
3.7.3 Land Disposal of Sludge 3-97
3.7.4 Distribution and Marketing 3-106

NOTES TO SECTION THREE 3-115

SECTION FOUR COSTS AND IMPACTS OF SLUDGE DISPOSAL REGULATIONS 4-1

4.1 Costs and Impacts of Regulatory Option 1 4-2

4.1.1 Costs and Impacts of Regulatory Option 1 Governing the Incineration of Sewage Sludge 4-4
4.1.2 Costs and Impacts of Regulatory Option 1 on POTWs Practicing Monofilling, Land Application, and Distribution and Marketing 4-38
4.1.3 Summary of Option 1 Compliance Costs 4-40

TABLE OF CONTENTS (continued)

Page

4.2 Costs and Impacts of Regulatory Option 2 4-40

4.2.1 Costs and Impacts of Regulatory Option 2 Concerning Sewage Sludge Incinerators 4-42
4.2.2 Costs and Impacts of Regulatory Option 2 Governing the Disposal of Sewage Sludge in Landfills 4-45
4.2.3 Costs and Impacts of Regulatory Option 2 Concerning the Land Application of Sewage Sludge 4-54
4.2.4 Costs and Impacts of Regulatory Option 2 Governing the Distribution and Marketing of Sewage Sludge 4-63
4.2.5 Summary of Compliance Costs for Option 2 4-70

4.3 Costs and Impacts of Regulatory Option 3 4-70

4.3.1 Costs and Impacts of Regulatory Option 3 Governing the Incineration of Sewage Sludge 4-72
4.3.2 Costs and Impacts of Regulatory Option 3 Governing Disposal of Sewage Sludge in Landfills 4-98
4.3.3 Costs and Impacts of Regulatory Option 3 Governing the Land Application of Sewage Sludge 4-110
4.3.4 Costs and Impacts of Regulatory Option 3 Governing the Distribution and Marketing of Sewage Sludge 4-131
4.3.5 Costs and Impacts of Regulatory Option 3 Governing Disposal of Sewage Sludge in Surface Impoundments 4-146
4.3.6 Summary of Compliance Costs for All Disposal Methods Under Regulatory Option Three 4-156

4.4 Costs and Impacts of Regulatory Option Four 4-156

4.4.1 Costs and Impacts of Regulatory Option 4 on POTWs Incinerating Sewage Sludge 4-158
4.4.2 Costs and Impacts of Regulatory Option 4 on POTWs Practicing Monofilling of Sewage Sludge 4-160
4.4.3 Cost and Impacts of Option 4 on POTWs Practicing Land Application of Sewage Sludge 4-163
4.4.4 Costs and Impacts of Regulatory Option 4 Governing the Distribution and Marketing of Sewage Sludge 4-185
4.4.5 Summary of Option 4 Compliance Costs 4-193

TABLE OF CONTENTS (continued)

Page

4.5 Summary and Comparison of Annual Compliance Costs Under the Four Regulatory Options 4-193

4.6 Impacts to Small Entities 4-197

NOTES TO SECTION FOUR 4-204

SECTION FIVE THE EFFECT OF PRETREATMENT ON SLUDGE QUALITY 5-1

5.1 Case Studies 5-3

5.2 The Cost to Industry of Implementing Stricter Pretreatment Programs 5-10

5.3 The Effect of Pretreatment on the Ability of the Case Study POTWs to Comply With the Proposed regulations 5-14

5.4 Limitations to the Analysis 5-19

SECTION SIX POPULATION RISK ASSESSMENT AND BENEFITS OF TECHNICAL REGULATIONS FOR SEWAGE SLUDGE USE AND DISPOSAL 6-1

6.1 General Framework for Risk-Based Benefit Analysis 6-1

- 6.1.1 Hazard Identification 6-5
- 6.1.2 Dose-Response Assessment 6-8
- 6.1.3 Exposure Assessment 6-9
- 6.1.4 Risk Characterization 6-11

6.2 Application of Risk-Based Methodology to Sewage Sludge Use and Disposal 6-11

- 6.2.1 Health Effects Information 6-13
- 6.2.2 Limitations/Uncertainty 6-17

6.3 Risk Assessment and Benefits Analysis for the Five Sludge Disposal Practices 6-20

- 6.3.1 Incineration 6-20
- 6.3.2 Sludge Monofilling 6-33
- 6.3.3 Land Application 6-39
- 6.3.4 Distribution and Marketing 6-49

6.4 Environmental and Other Business 6-53

NOTES TO SECTION SIX 6-56

TABLE OF CONTENTS (continued)

		Page
APPENDIX A	PRETREATMENT CASE STUDY ANALYSIS: INDUSTRY MODEL PLANT CHARACTERISTICS	A-1
APPENDIX B	DETAILED CALCULATIONS FOR EACH CASE STUDY POTW	B-1

GLOSSARY OF CHEMICAL ABBREVIATIONS

A/D	Aldrin/dieldrin
As	Arsenic
BAP, BAPYRENE	Benzo(a)pyrene
BEHP	Bis(2-ethylhexyl)phthalate
Cd	Cadmium
CLD	Chlordane
Cr	Chromium
Cu	Copper
DMN	Dimethylnitrosamine
HEPC	Heptachlor
Hg	Mercury
HXBE	Hexachlorobenzene
HXBU	Hexachlorobutadiene
LIN	Lindane
Mo	Molybdenum
Ni	Nickel
Pb	Lead
PCB	Polychlorinated biphenyls
Se	Selenium
TCE	Trichloroethylene
THC	Total hydrocarbons
TOX	Toxaphene
Zn	Zinc

SECTION ONE

EXECUTIVE SUMMARY

Section 405 of the Clean Water Act as amended in 1987 requires the Environmental Protection Agency (EPA) to regulate the use and disposal of sludge produced by wastewater treatment works. In response, EPA has proposed regulations governing five of the conventional practices for sludge use and disposal: incineration, landfilling in sludge-only monofills, land application, distribution and marketing and surface impoundments. Ocean disposal is not covered by this regulation because this disposal method was recently banned by Congress. This document is the regulatory impact assessment of the proposed sludge disposal regulations on publicly owned treatment works (POTWs).

Four regulatory options are discussed in this study. Each option defines maximum allowable pollutant concentrations in sewage sludge and minimum acceptable management practices (such as sludge testing) to ensure the maintenance of the desired level of protection. These regulatory options are described below. Note that the numbering of these options may not correspond to that used in the preamble. To avoid confusion, the reader should focus on the content of each option's requirements when comparing this discussion to that in the preamble.

1.1 The Regulatory Options

In Option 1, a sludge failing to pass the Toxicity Characteristic Leaching Procedure (TCLP) - a hazardous waste testing procedure - would be regulated as a hazardous waste under Subtitle C of RCRA. All other sludges would be managed under existing regulations except when limits on lead are exceeded in sewage sludge that is incinerated. Periodic sludge testing of pollutants is also required.

Option 2 sets a limit on the allowable pollutant concentrations in sludge disposed using the five regulated disposal practices. This option thus restricts the use and disposal of sludges that have considerably higher pollutant concentrations than those found in "typical" sewage sludges. These limits are derived by determining the 98th percentile concentrations of each contaminant of concern listed in the available EPA database of sludge contaminant levels. The lead limit for incinerated sludge, sludge pollutant testing requirements for all disposal methods, and labeling requirements for distributed and marketed sludge also apply under Option 2.

Option 3 is the basis of the proposed sewage sludge regulations. This option, in part, uses risk assessment methodologies to set maximum pollutant concentrations. The maximum concentrations limit risks to individuals when high levels of pollutant exposure are likely to occur, or when there are significant scientific uncertainties. For carcinogens, the basis for these concentration limits is the risk of cancer for the maximum exposed individual (MEI). The limits are set at levels that achieve a cancer risk of 10^{-5} or 10^{-4} (one cancer in a population of 100,000 or 10,000, respectively), depending on the type of disposal method used. For noncarcinogens, an appropriate human health criterion or a plant/animal toxicity value has been selected as a concentration limit. Option 3 also uses the 98th percentile concentrations (as defined above in the description of Option 2) to set pollutant limits for nonagricultural land application and surface impoundments - the disposal methods estimated to have the least impact on human health.

A number of management practices are required under Option 3. In addition to sludge testing for pollutants, which is required under all the regulatory options, other practices are also mandated. These practices include continuous monitoring and recording for incineration; runoff and runon controls for monofilling and surface impoundments; access and use controls, pathogen reduction and pathogen testing requirements for land application; and pathogen reduction, pathogen testing, sludge-product labeling requirements for distribution and marketing, and recordkeeping and reporting requirements for all disposal methods.

Option 4, like Option 3, bases the pollutant concentrations on risk assessment methodologies. Depending on the sludge disposal method, however, the MEI risk level used in Option 4 is generally more stringent than the risk level defined for Option 3. Option 4 covers all disposal methods (except surface impoundments, which are not addressed by Option 4) with risk-based requirements; the 98th percentile concentrations (which are not risk-based limits) are not used to set pollutant concentration limits. The same management practices are required under Option 4 as under Option 3.

1.2 Number and Type of Treatment Plants

There are currently 15,305 POTWs operating in the United States. More than 80 percent of these facilities are very small, processing less than 1 million gallons of wastewater per day (MGD). The larger facilities (processing more than 10 MGD) account for only about 3 percent of all POTWs, but they treat approximately 67 percent of the nation's wastewater.

POTWs apply varying levels of treatment to the incoming wastewater. The level of treatment - primary, secondary, advanced secondary, or advanced wastewater treatment - affects the volume of sludge generated per unit of influent. In general, the higher the level of treatment, the more sludge is generated. More than half the POTWs in the United States treat sewage to the secondary level. Thirty percent are designed to treat sludge more extensively than that achieved by secondary treatment. A minority, or approximately 14 percent, provide only primary treatment.

The disposal methods covered by the proposed regulations make up only a portion of the disposal methods used by POTWs in this country. Not included is sludge disposed at municipal landfills (codisposal). The number of POTWs using the regulated disposal methods and the volume of sludge generated by these facilities is presented in Table 1-1. These 5,367 POTWs, which represent approximately 35 percent of the total number of POTWs currently operating, generate approximately 55 percent of total annual sewage sludge volume. It is these 5,367 POTWs which will incur the costs of complying with the proposed regulations.

TABLE 1-1

THE NUMBER OF POTWS AND THE SLUDGE VOLUME ASSOCIATED WITH THE REGULATED DISPOSAL OPTIONS

DISPOSAL OPTION	TOTAL NUMBER OF POTWS	TOTAL VOLUME OF SLUDGE (MILLIONS OF DRY METRIC TONS)
Incineration	169	1.7
Ocean Disposal[a]	25	0.4
Sludge Monofills	49	0.1
Land Application	2,623	1.2
Distribution and Marketing	106	0.7
Surface Impoundments	2,395	0.2
Total	5,367	4.3

[a] Ocean disposal has been banned; these POTWs are assumed to shift to incineration.

Source: U.S. EPA. The 1986 Needs Survey.

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1.3 Costs and Benefits

The costs and benefits associated with the proposed regulations were developed using five model POTWs and three sludge profiles to represent the relevant characteristics of all POTWs affected by the proposed regulatory options. The POTWs affected by the proposed regulation were assigned to one of the five model plants based on the volume of wastewater processed at each POTW daily. The five model POTWs reflect five sizes: 0.1 MGD, 0.5 MGD, 2 MGD, 14 MGD and 128 MGD.

The three sludge profiles were developed using an EPA data base. The median, 90th percentile and 98th percentile contaminant concentrations were derived for all the regulated pollutants in sludge. The affected POTWs were assumed to generate one of these sludge types based on the percentage of industrial influent received by each plant (i.e., the POTWs receiving the highest percentages of industrial influent were assumed to generate 98th percentile sludge). Compliance with the maximum pollutant criteria was determined based on a comparison between pollutant levels in each of the profiles and the relevant criteria defined in each of the options. Baseline sludge disposal costs and incremental compliance costs, which were developed for each model facility size, were then used to calculate compliance costs. Total compliance costs were aggregated based on the numbers of POTWs assigned to each model that were estimated to fail to meet the relevant numeric criteria under each option.

The benefits associated with the regulatory options were estimated as the number of disease cases avoided annually. The numbers of baseline cancer and noncancer cases associated with the existing sludge disposal practices were established. The change (reduction) in the number of cases after regulatory controls were implemented constitute the benefits for each disposal method under each regulatory option.

The costs and benefits for all the disposal options are summarized in Table 1-2. A brief discussion of the regulatory controls required for each disposal method under each regulatory option and other relevant assumptions is

TABLE 1-2

SUMMARY OF COSTS AND BENEFITS OF THE PROPOSED REGULATORY OPTIONS
($1987)

	INCINERATION	OCEAN DISPOSAL	MONOFILL	LAND APPLICATION	DISTRIBUTION AND MARKETING	SURFACE IMPOUNDMENTS	TOTAL
Number of Facilities Using Disposal Practice							
	169	25	49	2,623	106	2,395	5,367
Baseline Aggregate Risk							
- Cancer (cases/year)	13[a]	NA	0.02	0.18	0.02	NE	13
- Other health effects (cases/year)	5,976[a]	NA	26	41.5	95	NE	6,138.5
Number of Facilities in Noncompliance							
Option 1	96	NA	0	0	0	NA	96
Option 2	97	NA	7	54	0	NA	158
Option 3	122	NA	49	278	35	25	509
Option 4	122	NA	49	2,623	35	NA	2,829
Annual Incremental Cost of Compliance ($ Million)[b]							
Option 1	$22.8	NA	$0.2	$4.1	$0.5	NA	$27.6
Option 2	22.8	NA	0.9	9.9	0.6	NA	34.3
Option 3	103.8	NA	25.5	15.2	7.8	5.3	157.6
Option 4	103.8	NA	25.5	244.3	25.4	NA	399.0
Risk Level to be Ensured by Meeting Limitations, in Terms of MEI							
Option 3	10^{-5}	NA	10^{-4}	10^{-4}	10^{-4}	NA	NA
Option 4	10^{-5}	NA	10^{-5}	10^{-5}	10^{-5}	NA	NA
Estimated Reduction in Aggregate Risk[b]							
- Cancer (cases avoided/year)							
Option 1	2.8	NA	0.00	0.00	0.00	0.00	2.8
Option 2	2.8	NA	0.01	0.06	0.00	0.00	2.9
Option 3	9.4	NA	0.02	0.06	0.02	NE	9.5
Option 4	7.3	NA	0.02	0.18	0.02	0.00	7.5
- Other health effects (cases avoided/year)							
Option 1	5,155	NA	0	0	0	0	5,155
Option 2	5,155	NA	0	4	0	0	5,159
Option 3	5,163	NA	26	21	56	NE	5,266
Option 4	4,759	NA	26	42	62	0	4,889

NE = Not estimated.

[a] Baseline risk includes the risks of incineration by POTWs that are required to cease ocean disposal.

[b] Incremental costs and benefits of the regulation associated with the 25 POTWs affected by the ocean ban are included in the costs and benefits for incineration.

Source: ERG and ABT Associates estimates.

presented below. Costs and benefits of each disposal method under each regulatory option are also presented.

1.3.1 Option 1

Incineration

TCLP concentrations define the limits for incineration for all sewage sludge constituents except mercury, beryllium and lead. All but the lead criterion are a part of the current regulatory (baseline) requirements, and concentrations of all other contaminants in sludge are expected to be less than the TCLP limits. Thus only the lead criterion has an impact on compliance costs. The lead criterion is set at 25 percent of the National Ambient Air Quality Standards (NAAQS) for lead following combustion and emission from the incinerator. Sludge testing is also required for all incinerators, at a frequency based on the size of the POTW.

Two groups of POTWs are affected. The first group currently incinerates sewage sludge. The second group is expected to shift to incineration as a result of the recent legislative ban on the ocean disposal of sludge (the ocean ban POTWs).

Two tiers of compliance with the lead criterion are possible for both groups of POTWs. At Tier 1, an incinerator is estimated to be in compliance if the sludge contains less than the limiting concentration for lead calculated using an incinerator control efficiency and an air dispersion factor established by Option 1. If the incinerator fails at Tier 1, emission testing and air dispersion modeling may be undertaken and a new limiting concentration calculated based on the values generated for the control efficiency for lead and air dispersion at that incinerator.

The analysis indicates that 96 POTWs out of 169 (180 incinerator units out of 282) are out of compliance with the lead criterion at Tier 2 among those

POTWs with existing incinerators. These 96 facilities are assumed to upgrade pollution control devices in order to meet the lead criterion. The ocean ban POTWs, however, are assumed to have installed wet ESPs or fabric filter pollution control devices as part of baseline permitting requirements, or because of public pressure or anticipation of more stringent requirements. These POTWs are thus estimated to pass the lead criterion at Tier 2.

Three control technology options were costed: wet electrostatic precipitators (ESPs), fabric filters, and dry scrubbers in combination with fabric filters. The ability of these devices to achieve the pollution control efficiencies required to bring every incinerator into compliance with the lead criterion is not well documented. For the purpose of analysis, however, it is assumed that wet ESPs or fabric filters could achieve the necessary pollution control.

The total annual compliance costs were estimated to be $22.8 million. These costs were derived assuming that all POTWs failing to meet the lead criterion retrofit wet ESPs. Costs may range from $20.6 million if all POTWs retrofit the least expensive option, fabric filters, to $155.9 million if all POTWs retrofit the most expensive option, dry scrubbers with fabric filters. These total compliance costs include not only the costs of retrofitting pollution control equipment, but also the costs of complying with sludge testing requirements (incurred by all POTWs) and costs of performing emissions testing and air dispersion modeling (incurred by 122 POTWs with 219 existing incinerators. The ocean ban POTWs are assumed to incur these costs to meet permit or other conditions.

The health effects associated with sewage sludge incineration were based on the dispersion of pollutants in the atmosphere from stack emissions and the subsequent inhalation of pollutants by populations in the vicinity of the incinerator. Other pathways of exposure (associated with deposition of pollutants on food crops and with disposal of scrubber water and incinerator ash) were not considered in the analysis. The benefits of the regulation, i.e., the reduction in annual cases of disease, were calculated based on the reduction in lead emissions achieved by wet ESPs. The annual cases of disease avoided due to the application of regulatory controls under Option 1 are 2.8 cancer cases and 5,155 noncancer cases. These reductions are solely attributable to POTWs that currently incinerate sewage sludge. The ocean ban POTWs, which are expected to pass the criteria at Tier 2, will not be required to reduce their emissions further and will thus not contribute to the annual reduction in disease cases.

Sludge Monofills

All monofilled sludge is expected to meet the TCLP criteria. Only sludge testing is incremental to current requirements. This cost totals $0.2 million annually. Since no incremental regulatory controls are applied, no cases of cancer or noncancer are avoided.

Land Application

All land-applied sewage sludge is expected to meet the TCLP criteria. Only sludge testing is incremental to current requirements. The cost for sludge testing totals $4.1 million annually. Since no incremental regulatory controls are applied, no cases of cancer or noncancer are avoided.

Distribution and Marketing

All sewage sludge that is distributed and marketed is expected to meet the TCLP criteria. Only sludge testing is incremental to current requirements. This cost totals $0.5 million annually. Since no incremental regulatory controls are applied, no cases of cancer or noncancer are avoided.

Surface Impoundments

Surface impoundments are not covered by Option 1.

Summary of Option 1

The total compliance costs associated with Option 1 (assuming that wet ESPs are chosen for pollution control devices on incinerators that are out of compliance with lead requirements) are $27.6 million. A total of 2.8 cancer cases and 5,155 noncancer cases are avoided under Option 1.

1.3.2 Option 2

Incineration

The same lead criterion specified by Option 1 applies under Option 2 since no additional incinerators that pass under Option 1 burn 98th percentile sludge, costs are identical under both options. Total annual compliance cost under Option 2 are $22.8 million.

The benefits of regulating incineration under Option 2 are calculated in the same way as those for Option 1. The annual cases of cancer avoided total 2.8 and the annual cases of noncancer avoided total 5,155. Again, the ocean ban POTWs do not contribute to this reduction in disease cases.

Sludge Monofills

For sludge monofills, the maximum pollutant concentrations in sludge under Option 2 are defined by the 98th percentile sludge concentrations. Thus by definition, the POTWs generating 98th percentile sludge are estimated to fail to meet the Option 2 criteria for sludge monofills. As a result, seven POTWs are estimated to incur compliance costs for shifting to alternative disposal methods. It is assumed that these POTWs choose either codisposal or incineration. Smaller POTWs (0.1 and 0.5 MGD) are assumed to be able to use codisposal. Larger POTWs are assumed to use incineration, since it is anticipated that the volume of waste generated by these facilities would have a large impact on current municipal landfill capacity problems.

Summary of Option 1

The total compliance costs associated with Option 1 (assuming that wet ESPs are chosen for pollution control devices on incinerators that are out of compliance with lead requirements) are $27.6 million. A total of 2.8 cancer cases and 5,155 noncancer cases are avoided under Option 1.

1.3.2 Option 2

Incineration

The same lead criterion specified by Option 1 applies under Option 2. Since no additional incinerators that pass under Option 1 burn 98th percentile sludge, costs are identical under both options. Total annual compliance cost under Option 2 are $22.8 million.

The benefits of regulating incineration under Option 2 are calculated in the same way as those for Option 1. The annual cases of cancer avoided total 2.8 and the annual cases of noncancer avoided total 5,155. Again, the ocean ban POTWs do not contribute to this reduction in disease cases.

Sludge Monofills

For sludge monofills, the maximum pollutant concentrations in sludge under Option 2 are defined by the 98th percentile sludge concentrations. Thus by definition, the POTWs generating 98th percentile sludge are estimated to fail to meet the Option 2 criteria for sludge monofills. As a result, seven POTWs are estimated to incur compliance costs for shifting to alternative disposal methods. It is assumed that these POTWs choose either codisposal or incineration. Smaller POTWs (0.1 and 0.5 MGD) are assumed to be able to use codisposal. Larger POTWs are assumed to use incineration, since it is anticipated that the volume of waste generated by these facilities would have a large impact on current municipal landfill capacity problems.

Additionally, sludge testing costs are incurred by all POTWs except for those shifting to codisposal in municipal landfills. Requirements for initial testing to determine whether sludge can be monofilled are assumed to be fulfilled when sludge is tested to determine whether it is hazardous under RCRA requirements. Thus costs for initial testing are not credited to any of the proposed sewage sludge regulatory options. Subsequent testing is only required for POTWs practicing the disposal methods covered by the regulatory options. Codisposal is not covered under any of the regulatory options, thus sludge testing is not required for sludges going to municipal landfills. A total of $0.9 million is incurred in annual compliance costs (including both shifting and testing costs) by facilities using sludge monofills for disposal under Option 2.

The benefits of regulating sludge monofills were estimated based primarily on the effects of pollutants leaching into underlying aquifers that supply drinking water. Pollutants escaping to the atmosphere were also considered. The risks of shifting to incineration are included in the benefits of regulating incineration. The annual benefits associated with the regulatory controls imposed on monofilled sludge by Option 2 are 0.01 cancer cases avoided and no noncancer cases avoided.

Land Application

There are several different groups of land application end uses, including agricultural, land reclamation, dedicated disposal, silvicultural (forest land application) and other, which includes nurseries, sod farms, home gardens, golf courses, etc. All end uses (except silviculture, which is an experimental practice) are currently employed by land-applying POTWs. These practices are covered by one set of criteria under Option 2.

The data did not distinguish between POTWs practicing land application and distribution and marketing, so POTWs that compost their sludge were assumed to practice distribution and marketing. POTWs that did not compost their sludge were assumed to practice land application.

POTWs generating 98th percentile sludges, regardless of land application end use, are estimated to fail the Option 2 land application criteria (54 POTWs). These POTWs are assumed to shift to alternative disposal practices. The alternative practices estimated to be chosen include codisposal, and composting with continued land application. Again, only the smallest POTWs are assumed to be able to choose codisposal. Composting is available as an alternative since this process dilutes the contaminants in sludge. Thus when 98th percentile sludges are composted, the levels of contaminants in these sludges drop below the levels defined as 98th percentile criteria. The only management practice required under Option 2 that is incremental to current practices is sludge testing. The costs for shifting disposal practices and sludge testing total $9.9 million annually.

The benefits associated with the regulatory control of agricultural land application were based on three dietary pathways of exposure: human consumption of crops grown on sludge-amended soil; human consumption of meat and dairy products from animals that have ingested feed or pasture grasses grown on sludge-amended soils; and human consumption of beef, dairy products or lamb from animals that directly ingest sludge from pasture grasses. Pathways of exposure associated with nonagricultural land application are the human consumption of drinking water from contaminated ground water and surface water sources; and the consumption of fish and shellfish from contaminated surface water.

The total cases of disease avoided due to regulatory control of both agricultural and nonagricultural land application was based on the net effect of POTWs with 98th percentile sludges shifting to the alternative disposal practices outlined above. For agricultural land application, 0.05 cancer cases and 4.6 noncancer cases are estimated to be avoided annually under Option 2. For nonagricultural land application, less than 0.01 cancer cases and -0.55 noncancer cases are estimated to be avoided annually. Cancer cases avoided for both agricultural and nonagricultural kind application total 0.06; noncancer cases avoided total 4.

Distribution and Marketing

All POTWs generating noncomposted 98th percentile sludges are estimated to fail to meet the Option 2 criteria for distribution and marketing. POTWs were classified as practicing distribution and marketing, however, if they composted their sludge as discussed above. Thus the pollutant concentrations in all sludges defined to be distributed and marketed are diluted, making it possible for the sludges to meet the criteria. No POTWs practicing distribution and marketing are estimated to shift to alternative practices under Option 2.

Management practice requirements include labeling and handout development and sludge testing. Total compliance costs, which include only the costs of management practice requirements are $0.6 million.

Since no regulatory controls are applied using Option 2 criteria, there are no net changes in the health risks associated with distribution and marketing. No cases of cancer or noncancer are avoided.

Surface Impoundments

Surface impoundments are not covered by Option 2.

Summary of Option 2

The total compliance costs associated with Option 2 (assuming that wet ESPs are chosen for pollution control devices on incinerators that are out of compliance with lead requirements) are $34.3 million. A total of 2.9 cancer cases and 5,159 noncancer cases are avoided annually under Option 2.

1.3.3 Option 3

Incineration

Under Option 3 requirements, incinerator emissions must meet numeric criteria for eight pollutants, including seven metals and total hydrocarbons. Management practice requirements include monitoring and recording and sludge testing. As for Options 1 and 2, compliance can be demonstrated at either Tier 1 or at Tier 2 following emissions testing and air dispersion modeling. Under Option 3, all POTWs with existing incinerators fail at Tier 1 and are assumed to incur emission testing and air dispersion modeling costs. Twenty-two ocean ban POTWs fail at Tier 1, but are assumed to have performed emission testing and air dispersion modeling as part of their baseline permitting requirements or other conditions. A total of 122 POTWs with 219 existing incinerators fail to meet criteria for either metals or metals and hydrocarbons; of these, 28 POTWs with 61 existing incinerators fail to meet criteria for hydrocarbons. Ocean ban POTWs are estimated to pass all criteria. Those incinerators which do not meet criteria for metals are assumed to retrofit wet ESPs, while those which do not meet criteria for hydrocarbons are assumed to install afterburners and heat exchangers. Implicit in this is the assumption that retrofitting wet ESPs and afterburners will allow all incinerators to meet the criteria. Total compliance costs include costs for retrofits, costs for emissions testing and air dispersion modeling, costs for monitoring and recording of incinerator parameters, and costs for sludge monitoring, recordkeeping, and reporting. These costs, which total $103.8 million, could range as low as about $101 million if all POTWs retrofit fabric filters or as high as about $266 million if all POTWs retrofit dry scrubbers with fabric filters (assuming afterburners would still be needed).

The benefits of controlling sludge incinerators under Option 3 are calculated assuming that wet ESPs and afterburners are installed on incinerators out of compliance with metal criteria and hydrocarbon emissions criteria, respectively. The control efficiencies of this equipment are used to calculate the quantities of pollutants removed from incinerator emissions, which in turn are used to determine the reductions in risks to human health from the incineration of sewage sludge. The reductions in risk resulting from controls on incinerator emissions are the benefits of the Option 3 requirements for incinerators and are expressed as numbers of disease cases avoided. Also included in the net benefits are the risks of shifting from current disposal practices to incineration. The risks associated with incineration are greater than those for other disposal practices; thus, the benefits of shifting sludge to incineration are negative. Net benefits for controlling incineration under Option 3 are positive, however. Annually, 9.4 cases of cancer and 5,163 cases of noncancer are avoided. The ocean ban POTWs do not contribute to this reduction in risk.

Sludge Monofills

The analysis of the criteria for monofills showed that none of the POTWs would meet the numeric limits. It was assumed that all POTWs shift disposal practices. Thus 49 POTWs were assumed to shift to codisposal or incineration, depending on POTW size. Those shifting to incineration were also estimated to incur sludge management practice costs. (Codisposal is not covered by the proposed regulatory options, thus POTWs shifting to codisposal are not required to test their sludge other than initially to determine whether the sludge is in compliance with monofill criteria. As discussed previously, initial testing costs are assumed attributable to RCRA requirements.) Total costs of shifts in disposal practices and for sludge testing, continuous monitoring, performance testing, and recordkeeping and reporting for incinerated sludge are estimated at $25.5 million annually.

The benefits were calculated the same way as for Option 2. The annual benefits associated with Option 3 controls on monofilling are 0.02 cancer cases avoided annually and 26 noncancer cases avoided annually.

Land Application

The compliance costs for POTWs using land application also reflect the need for POTWs that fail the applicable agricultural or nonagricultural criteria to shift to alternative practices. The analysis indicates that all POTWs with typical sludge quality pass the numeric criteria (2,278 POTWs out of 2,623 POTWs). All POTWs generating 90th percentile sludges that employ nonagricultural end uses also pass the numeric criteria (67 POTWs). POTWs with 90th and 98th percentile sludges employing agricultural end uses (224 and 42 POTWs, respectively) and those with 98th percentile sludges employing nonagricultural end uses (12 POTWs) are estimated to fail the criteria. These facilities are assumed to shift to alternative disposal practices. The assumed shifts in disposal practice depend on the quality and/or end use of the sludge. POTWs with 90th percentile sludges employing agricultural end uses (224 facilities) are expected to shift to nonagricultural end uses. All POTWs (54) generating 98th percentile sludges (regardless of end use) are assumed to shift to codisposal, composting with nonagricultural land application, or incineration, depending on the availability and cost effectiveness of the disposal method.

In addition to costs of shifting to alternative disposal methods, compliance costs are also incurred for sludge testing of pollutants and pathogens, and recordkeeping and reporting requirements (including writing contracts to ensure the Option 3 requirements are fulfilled no matter who is the ultimate end user of the sludge). Total annual compliance costs under Option 3 for POTWs practicing land application are $15.2 million.

The estimate of the benefits associated with regulatory control of land application was based on the same pathways used for estimating benefits under Option 2. The benefits are calculated based on the shifts in disposal practices assumed to be made, as described above (except risks of shifting to incineration, which were counted under the net benefits of regulating incineration). For agricultural land application, total annual benefits are 0.15 cancer cases and 28 noncancer cases avoided. For nonagricultural land application, total annual benefits are -0.09 cancer cases and -7 noncancer cases avoided. Total annual benefits for all types of land application are, therefore, 0.06 cancer cases avoided and 21 noncancer cases avoided.

Distribution and Marketing

The analysis of the distribution and marketing criteria indicated that only typical sludges would meet these criteria (71 POTWs). It was assumed that all 35 POTWs failing to meet the criteria would either meet the definition of nonagricultural land application, or shift to incineration. Costs of bringing the sludge under contractual control, labeling sludge products, sludge testing, and recordkeeping and reporting are also included as compliance costs. The total annual compliance costs are estimated to be $7.8 million.

The baseline risks of distribution and marketing are based on the use of composted sludge in home gardens and for nonresidential purposes. The human ingestion of produce from home gardens and the ingestion of the compost directly due to "pica" behavior in children were the exposure pathways studied for sludge applied to residential land. Groundwater and surface water pathways were studied to determine risks of sludge applied to nonresidential land.

The change in risks due to imposing regulatory controls was based on the health effects of POTWs shifting from distribution and marketing. A total of 0.02 cancer cases and 56 noncancer cases was estimated to be avoided annually.

Surface Impoundments

A total of 2,395 POTWs are estimated to use surface impoundments as their means of disposing of sludge. Of these, only 25 are expected to fail the criteria for surface impoundments. Most of the costs are thus associated with meeting management practice requirements. The POTWs that do shift to alternative disposal methods are expected to shift to codisposal or composting with dedicated land application. Total costs of compliance for surface impoundments are estimated to be $5.3 million.

Benefits of surface impoundments have not yet been estimated.

Summary of Option 3

The total compliance costs associated with Option 3 (assuming that wet ESPs are chosen for pollution control devices on incinerators that are out of compliance with Option 3 metals requirements) are $157.6 million. An estimated 9.5 cancer cases and 5,266 noncancer cases are avoided annually under Option 3. These benefits do not include those associated with control of surface impoundments. The benefits of controlling surface impoundments will be calculated in subsequent versions of the RIA.

1.3.4 Option 4

Incineration

The requirements of Option 4 for POTWs that incinerate sewage sludge are identical to those for Option 3. Thus total costs of compliance (assuming wet ESPs are chosen as control devices) are $103.8 million. Benefits are not the same, however, since the risks of shifting sludge from current disposal methods to incineration have been included, and more POTWs are estimated to shift to incineration under Option 4 requirements than under Option 3 requirements. Annually, 7.3 cancer cases and 4,759 noncancer cases are estimated to be avoided.

Sludge Monofills

The analysis of Option 4 criteria indicate that all POTWs currently practicing monofilling fail to meet the criteria (49 POTWs). All these POTWs are assumed to shift to alternative disposal practices, either codisposal or incineration, depending on POTW size. These shifts are the same as those estimated for Option 3, thus the compliance costs for monofilling are the same under Options 3 and 4. A total of $25.5 million is estimated to be incurred as annual compliance costs under Option 4.

The benefits are the same as those calculated for Option 3; 0.02 cancer cases and 26 noncancer cases are estimated to be avoided annually.

Land Application

The analysis of the criteria proposed under Option 4 indicate that all 2,623 POTWs will fail to meet these criteria. It is thus anticipated that all POTWs will shift to alternative disposal practices, which include codisposal, distribution and marketing or incineration, depending on availability and cost effectiveness of the disposal method for each POTW size class. Testing, recordkeeping and reporting costs will also be incurred for those POTWs that shift to distribution and marketing or incineration. Also, POTWs shifting to distribution and marketing are assumed to compost their sludge to meet pathogen reduction requirements and are thus estimated to incur the cost of composting. These POTWs will also have to label their sludge product to meet distribution and marketing requirements. The total costs of shifting disposal practices, sludge testing, recordkeeping and reporting, composting, and labeling are $244.3 million.

The benefits are calculated as the net health effects of POTWs shifting from land application to the alternative practices listed above (except incineration, the net benefits of which have been included under the analysis of incineration). The pathways of exposure considered in the analysis are the same as those considered for land application under Options 2 and 3. An estimated 0.18 cancer cases and 42 noncancer cases are avoided annually.

Distribution and Marketing

The analysis of Option 4 criteria indicate that all POTWs generating 90th and 98th percentile sludges will fail to meet the criteria. These POTWs are assumed to shift to incineration. Compliance costs also include costs of sludge testing, recordkeeping and reporting for all sludges and sludge product labeling for typical sludges, which meet the Option 4 criteria. Total costs of regulating distribution and marketing under Option 4 are $25.4 million.

Benefits are calculated based on the net health effects of all POTWs failing the criteria shifting from distribution and marketing (risks of shifting to incineration were calculated under the analysis of incineration benefits). The pathways of exposure considered are the same as those considered for distribution and marketing under Option 3. An estimated 0.02 cancer cases and 62 noncancer cases are estimated to be avoided annually.

Surface Impoundments

Surface impoundments are not covered by Option 4.

Summary of Option 4

The total compliance costs associated with Option 4 (assuming wet ESPs are chosen for pollution control devices on incinerators that are out of compliance with Option 4 metals requirements) are $399.0 million. An estimated 7.5 cancer cases and 4,889 noncancer cases are avoided annually under Option 4.

1.4 Effect of Pretreatment on Sludge Quality

Typically, limiting the level of pollutants discharged into sewers will reduce the level of contaminants in sludge. To address this and other concerns regarding nondomestic discharges to POTWs, EPA has implemented the National Pretreatment Program. This program requires POTWs that process over 5 MGD (or others with significant industrial users) to establish pretreatment programs. The pretreatment programs impose pollutant-specific discharge limits (local limits) for industrial dischargers to municipal sewers. These local limits implement the categorical pretreatment standards (which are specific to each industry and prescribe technological controls to treat industrial discharges) and the national prohibited discharge standards (which prohibit certain destructive or volatile discharges such as acidic or explosive wastes).

The purposes of these local limits and the requirements imposed on all industrial users of POTWs in the general pretreatment regulations are to prevent pass-through of inadequately treated pollutants to surface waters, and interference with the treatment plant facilities, processes, and operations, including sludge processes and disposal. Thus, the National Pretreatment Program seeks to achieve, among other goals, compliance with sludge use and disposal standards.

A major element of the National Pretreatment Program is the categorical pretreatment standards. These uniform, national standards are based on pollutant reductions achievable using a specified level of technology - usually the equivalent of the "best available technology economically achievable" standard that applies to direct dischargers in the same industry. Categorical pretreatment standards apply to approximately 15,000 industrial users of POTWs in approximately 30 industry categories. To achieve compliance with the new sludge disposal standards, POTWs could consider additional pretreatment requirements on their industrial users. One approach would be to require categorical users to achieve pollutant reductions beyond those required by the categorical pretreatment standards (referred to in this document as "tighter" or "stricter" pretreatment controls).

Eight case studies were conducted to analyze the effectiveness of tighter pretreatment controls in attaining compliance. The case studies focused on pollutant removals attainable by those industries covered by categorical pretreatment standards using the best available technologies. The case studies did not account for removals that might be achieved through locally imposed pretreatment requirements on other industries. Depending on the site-specific conditions, imposing local limits could significantly improve sludge quality.

Potential improvements in the removals of 10 pollutants as a result of stricter pretreatment controls were estimated based on actual POTW data on industrial influent, overall plant influent, and sludge quality. The results of the case study analyses are presented in Table 1-3. The table presents the additional percent removals specific to each pollutant expected if certain

TABLE 1-3

ESTIMATED PERCENT REDUCTION IN POLLUTANTS FOR CASE STUDY POTWs

POTW	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	BEHP
River Road	1.0	4.4	1.4	0.2	-	98.5	0.5	-
Newburyport	1.75	0.92	1.39	1.74	-	6.9	0.85	-
Muscatine	0.9	98	1.1	20.9	-	13.1	0.5	-
Goshen	97	99	4.0	41.1	-	11.1	47.7	-
Passaic Valley	10.1	100	55	15.7	-	100	10.2	-
Westerly	49.9	95.4	87.2	96	-	94.3	98.3	-
Trinity	17.4	97.5	9.4	9.2	-	65.9	17.3	-
Greenbay	0.5	11.4	2.4	6.1	0	6.9	41.0	-
Average	22.3	63.3	20.2	23.9	ID	49.6	27.0	-

ID = Insufficient data.

Source: ERG analyses.

Note: Percent reductions apply to the current influent pollutant loadings.

industrial contributors install the best pretreatment technology available. Although significant improvements in certain pollutants can be achieved, only one of the case study POTWs came into compliance with Option 3 criteria when stricter pretreatment controls were applied.

SECTION TWO

INTRODUCTION

2.1 Scope

This report evaluates the cost, benefits, and economic impacts of the proposed regulations pertaining to the disposal of wastewater sludge generated by publicly owned treatment works (POTWs). EPA has developed these regulations as required under Sections 405(d) and (e) of the Clean Water Act as amended in 1987. This report evaluates the proposed regulation and three alternatives: a low-impact option (Option 1); a moderate-impact option (Option 2), which affects only those POTWs generating the most contaminated sludges; the proposed regulatory option (Option 3); and the most stringent option (Option 4). The numbering of these options differs from that presented in the preamble. To avoid confusion, the reader should focus on the requirements of the options rather than their numbers when comparing discussions of the options in this RIA with those in the preamble.

The proposed regulations cover all municipal wastewater treatment works, except for privately owned treatment works operated in conjunction with industrial manufacturing and processing facilities. This RIA, however, pertains only to POTWs.

POTWs generate sludge at several stages of the sewage treatment process. Six conventional sludge disposal practices are used predominantly: (1) landfilling, (2) incineration, (3) ocean disposal, (4) surface impoundments (lagoons), (5) distribution and marketing (the giveaway or sale of sludge as a fertilizer product), and (6) land application, which encompasses several major end use categories: dedicated land disposal, land reclamation, silviculture, agricultural land application, and others such as parks, golf courses, sod farms and nurseries. The proposed regulations govern five of these six disposal methods separately; ocean disposal has recently been banned and the POTWs practicing this disposal method have been assumed to shift to incineration in characterizing baseline practices. In most cases, these ocean ban POTWs are discussed with those currently incinerating sludge.

As a result of the proposed sewage sludge regulations, POTWs may be required to alter their sludge disposal practices. The costs and the economic impacts of these changes are evaluated in this report. Health risks associated with wastewater sludge disposal will be reduced as a result of compliance. These benefits are also quantified.

2.2 Organization

The report is organized into six sections, which include Section One, the Executive Summary, and Section Two, Introduction. Section Three provides a profile of the wastewater treatment industry, including the types of treatment plants, the number and size of plants, and the distribution of sludge disposal methods among POTWs. Section Four analyzes the costs associated with the proposed requirements for each of the four regulatory options and examines special impacts to small entities. Several case studies are presented in Section Five to assess the importance of pretreatment in the context of the proposed regulations. Finally, Section Six summarizes the baseline risk of sludge disposal and provides estimates of the reduction in risk associated with the proposed regulations.

2.3 Data Sources

Several data sources were used to develop this report. Specific sources are referenced within the text and appendices. Some general sources of information include:

- 1986 Needs Survey Data Tapes and Summaries of Technical Data, U.S. Environmental Protection Agency (EPA).
- EPA publications concerning wastewater sludge disposal and sludge quality.

- Telephone contacts with POTW personnel.
- Industry specialists - public and private sector.
- EPA Regional and Headquarters technical staff.

SECTION THREE

PROFILE OF SLUDGE GENERATION, TREATMENT, USE, AND DISPOSAL

Every large city and many smaller communities are served by systems of drains, underground sewers, and pumping stations (i.e., a sewage collection system) that convey wastewater away from houses, commercial businesses, and industrial plants. The sewage collection system transports the wastewater to a wastewater treatment plant, referred to as a publicly owned treatment works (POTW). The treatment plant removes contaminants from the wastewater and discharges the purified water, usually into a nearby surface water body such as a river, lake, bay, or ocean. The residue of the treatment process, which contains the solids that have been removed, is referred to as municipal wastewater sludge. The use and the disposal of this sludge are addressed by the proposed regulations.

Table 3-1 shows the distribution of the wastewater treatment service provided throughout the United States. Over 74 percent of the U.S. residential population is served by sewers and POTWs. Another 15 percent of the U.S. population lives in communities that are served by POTWs, but are not connected to a sewer system. The remainder of the communities are served by a variety of other wastewater disposal methods, such as septic tanks, lagoon disposal systems, or systems that provide only preliminary treatment (e.g., filtration with coarse screens) prior to sewage discharge.

The data reported in Table 3-1 were derived from the Needs Survey, a comprehensive data collection effort by EPA that provides statistical information on many aspects of sewage collection systems and wastewater treatment plants. The Needs Survey of 1986 reported a nationwide total of 15,305 wastewater treatment plants (see Table 3-2).

Table 3-2 provides a breakdown of wastewater treatment capacity by size class of facility. Most treatment facilities are in the smaller size classifications, but the majority of the wastewater is processed in the 2

TABLE 3-1

RESIDENTIAL POPULATION SERVED BY WASTEWATER TREATMENT SYSTEMS

TYPE OF SERVICE	POPULATION SERVED (IN THOUSANDS)	PERCENT OF TOTAL POPULATION
Wastewater treated at a treatment plant.	169,630	73.7
Part of area with an established sewage authority but not connected to a central collection system.[a]	34,006	14.8
Dispose of wastewaters by means of individual onsite systems, the majority being septic tanks or leach fields.	12,390	5.4
Wastewaters receive treatment at facilities that do not discharge to surface waters, the majority being lagoon systems designed for evaporation and/or infiltration of the total flow. Also included are facilities that dispose of wastewater on land.	5,539	2.4
Served by a collection system, but wastewater receives only preliminary treatment (such as filtration by coarse screens) prior to discharge.	1,643	0.7
Not reported in any service category.	6,867	3.0
Total	230,075	100.0

[a] Wastewater disposal methods not reported in the data.

Source: The 1984 Needs Survey, Summaries of Technical Data, EPA. (Summaries of the same data were not available for the 1986 Needs Survey.)

1505S

TABLE 3-2

VOLUMES OF WASTEWATER PROCESSED BY TREATMENT FACILITIES IN EACH SIZE CLASS

SIZE CLASS (Millions of Gallons Per Day Processed)	NUMBER OF FACILITIES	PERCENTAGE OF FACILITIES (%)	WASTEWATER PROCESSED (Millions of Gallons Per Day)	PERCENTAGE OF WASTEWATER PROCESSED (%)	AVERAGE WASTEWATER PROCESSED PER FACILITY (MGD/Facility)
0.0-0.2	8,457	55	625	2	0.07
0.2-1.0	4,141	27	1,995	7	0.5
1.0-10.0	2,288	15	6,805	25	3.0
10.0-60.0	347	2	7,441	27	21.4
Greater than 60.0	72	1	10,859	40	150.8
Total	15,305	100.0	27,726	100.0	1.8

Source: The 1986 Needs Survey, EPA.

Note: Totals may not add exactly due to rounding.

largest facility size classes. Although just 3 percent of all facilities process more than 10 million gallons per day (MGD), these larger facilities account for 67 percent of all wastewater treatment in the United States.

3.1 Wastewater Treatment

The 15,305 wastewater treatment facilities throughout the country provide various levels of pollutant removal. The level of treatment employed in a given plant determines, in part, the purity of the plant's effluent and the quantity and pollutant content of the plant's sludge. The successive levels of treatment may be described as follows: pretreatment, preliminary treatment, primary treatment, secondary treatment, advanced treatment, and no discharge.[1]

3.1.1 Pretreatment

The pollutants entering a wastewater treatment facility come from the domestic, commercial, and industrial users of the sewage system. An initial means of reducing the pollutant levels in a sewage system is to require the users of the system to remove pollutants from their wastewater prior to discharge into the sewer. This practice is known as pretreatment. Some POTWs have had pretreatment programs in place for more than 50 years. These programs require removal of pollutants as a condition of sewer use. Historically, these local pretreatment regulations typically limited the discharge of conventional pollutants (e.g., oil and grease) into the sewage system. These regulations were intended to prevent clogging and corrosion of the sewers as well as interference and breakdowns at the wastewater treatment plant.

The federal government took an active role in pretreatment with the establishment of the National Pretreatment Program in 1981. A major goal of this program is to limit the flow of toxic industrial pollutants (e.g., heavy metals) into sewers by requiring industry to remove these pollutants prior to discharge. The federal program focused on toxic industrial pollutants for several reasons. First, these pollutants can destroy or inhibit the microorganisms that are used in the treatment system at most wastewater treatment plants, thereby rendering the plant ineffective or reducing its effectiveness in removing pollutants. Second, most wastewater treatment plants are not designed to remove toxic industrial pollutants. Thus, these substances can pass through the treatment plant unaltered, resulting in pollution of the surface water receiving the plant's effluent. Finally, if toxic industrial pollutants are removed at the wastewater treatment plant, the plant's sludges can become contaminated, thus, more difficult and expensive to dispose. For example, if excessive amounts of cadmium are removed from the wastewater, there may be a high level of cadmium in the plant's sludge, possibly making the sludge unsuitable for land application.

The National Pretreatment Program consists of two major components: (1) national pretreatment standards, which include categorical standards and prohibited discharge standards; and (2) local pretreatment programs. National categorical pretreatment standards place uniform national restrictions on the discharge of pollutants into sewers by the major industries. Overall, approximately 30 industrial categories are subject to uniform national standards (i.e., categorical pretreatment standards.) All plants in these industries must pretreat their wastewater prior to discharge into the sewers. Table 3-3 lists the categorical standards along with relevant rulemaking dates. Note that the compliance dates for most pretreatment standards fall between 1984 and 1988. Thus, the effect of the national categorical pretreatment standards in lowering the level of contaminants in POTW sludges has been realized only in recent years

Under the second major component of the National Pretreatment Program, local POTWs are required to: (1) establish pretreatment programs that enforce the national standards and any additional requirements (i.e., local limits) necessary to protect the integrity of the treatment plant and local surface water; and (2) to ensure compliance with federal or local requirements applicable to the POTW's chosen sludge disposal practice. All POTWs with a design flow greater than 5 million gallons per day or with significant industrial discharges are required to develop programs. Table 3-4 presents

TABLE 3-1

INDUSTRIES COVERED BY CATEGORICAL PRETREATMENT STANDARDS

INDUSTRY CATEGORY	DATE STANDARD WAS ISSUED IN FEDERAL REGISTER	EFFECTIVE DATE	COMPLIANCE DATE FOR EXISTING SOURCES[a]
Timber Products	1-26-81	3-30-81	1-26-84
Electroplating	1-28-81 7-15-83	3-30-81 8-29-83	4-27-84 (Non-integrated)[b] 7-15-86 (TTO)[b]
Iron & Steel	5-27-82	7-10-82	7-10-85
Inorganic Chemicals I	6-29-82	8-12-82	8-12-85
Textile Mills	9-02-82	10-18-82	c
Petroleum Refining	10-18-82	12-01-82	12-01-85
Pulp, Paper, Paperboard	11-18-82	1-03-83	7-01-84
Steam Electric	11-19-82	1-02-83	7-01-84
Leather Tanning	11-23-82	1-06-83	11-25-85
Porcelain Enameling	11-24-82	1-07-83	11-25-85
Coil Coating I	12-01-82	1-17-83	12-01-85
Electrical & Electronic Components I	4-08-83	5-19-83	7-01-84 (TTO)[d] 11-08-85 (As)[d]
Metal Finishing	7-15-83	8-29-83	6-30-84 (Part 433, TTO)[e] 7-10-85 (Part 420, TTO)[e] 2-15-86 (Final)[e]
Copper Forming	8-15-83	9-26-83	8-15-86
Aluminum Forming	10-24-83	12-07-83	10-24-86
Pharmaceuticals	10-27-83	12-12-83	10-27-86
Coil Coating (Canmaking)	11-17-83	1-02-84	11-17-86
Electrical and Electronic Components II	12-14-83	1-27-84	7-14-86
Non-Ferrous Metals I	3-8-84	4-23-84	3-09-87
Battery Manufacturing	3-09-84	4-23-84	3-09-87
Inorganic Chemicals II	8-22-84	10-05-84	6-29-85 8-22-87 ($CuSO_4$, $NiSO_4$)
Plastics, Molding and Forming	12-17-84	1-30-85	g
Non-Ferrous Metals Forming	8-23-85	10-07-85	8-23-88
Non-Ferrous Metals II	9-20-85	11-04-85	9-20-88
Pesticides		h	
Metal Molding and Casting (Foundries)	6-85	8-85	8-88
Organic Chemicals and Plastics and Synthetic Fibers[f]	11/87	12/21/87	11/5/90

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[a] The compliance date for any new source is the same date as the commencement of the discharge.

[b] Integrated electroplators are establishments both in electroplating and in other activities that are regulated by other EPA categorical pretreatment standards. Non-integrated electroplators are establishments involved in electroplating only. The compliance date for removal of total toxic organics (TTO) is July 15, 1986.

[c] No numerical pretreatment limits have been established for these industrial categories, and there is no final compliance date for categorical pretreatment standards. Firms in these categories are required to comply only with the General Pretreatment Regulations in 40 CFR 403.

[d] The compliance date for existing Phase I Electrical and Electronic Components manufacturers for TTO is July 1, 1984. The compliance date for arsenic is November 8, 1985.

[e] Existing sources that are subject to the metal finishing standards in 40 CFR Part 433 must comply only with the interim limit for Total Toxic Organics (TTO) by June 30, 1984. Plants also covered by 40 CFR Part 420 must comply with the interim TTO limit by July 10, 1985. The compliance date for metals, cyanide, and final TTO is February 15, 1986, for all sources.

[f] Regulations for this category have been proposed. Parentheses indicate expected dates.

[g] As of July 1987, no PSES standards have been promulgated for these industries.

[h] Regulation has been remanded to the administrator to be rewritten.

Source: U.S. Environmental Protection Agency, 1987.

TABLE 3-4

POTWs REQUIRED TO ESTABLISH PRETREATMENT PROGRAMS[a]
(Number of POTWs)

EPA REGION	EPA REQUIRED	EPA APPROVED	STATE REQUIRED	STATE APPROVED	TOTAL REQUIRED	TOTAL APPROVED
I	71	62	13	13	84	75
II	57	57	23	22	80	79
III	116	116	22	22	138	138
IV	39	34	369	352	408	386
V	91	88	241	229	332	317
VI[c]	98	95	28	27	126	122
VII	16	15	62	62	78	77
VIII	40	38	13	13	53	51
IX	120	120	1	1	121	121
X	15	15	29	29	44	44
Totals	663	640	801	770	1,464[b]	1,410

[a] Ten unapproved programs are currently under referral.

[b] Includes 42 unapproved programs that were recently identified as needing to develop pretreatment programs.

Source: U.S. EPA, Office of Water Enforcement and Permits, December 31, 1987.

1508S

the number of POTWs in each EPA region required to establish pretreatment programs. (Figure 3-1 shows the location of the EPA regions.) As indicated in the table, many states have been given the authority by EPA to administer a pretreatment program. Overall, 1,464 POTWs are required to establish local pretreatment programs. These large treatment facilities are responsible for over 75 percent of the municipal wastewater sludge generated in the United States. As of December 31, 1987, 1,410 of these POTWs had received approval of their programs from EPA or state authorities. The impact of these programs on the level of contaminants in municipal wastewater sludge is discussed in Section 3.5 and in Section Five of this report.

3.1.2 Preliminary Treatment

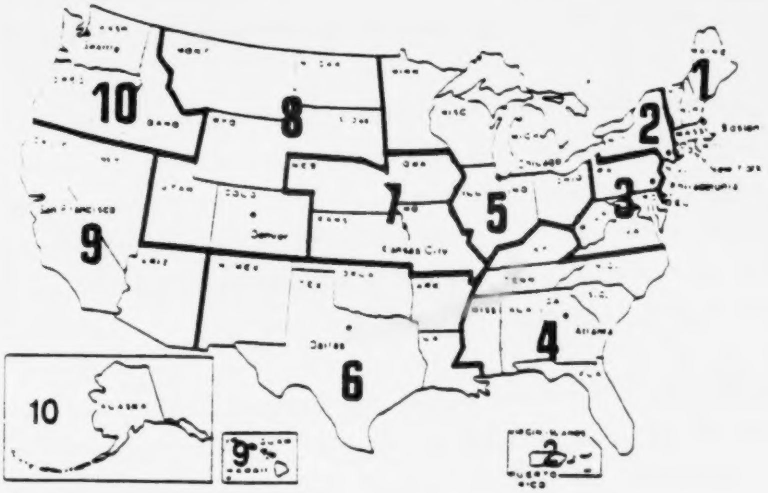
The raw sewage entering the wastewater treatment plant is more than 99 percent water, but also contains a number of solid and dissolved contaminants, including leaves, rocks, gravel, sand, twigs, human wastes, bits of garbage from kitchen disposals, and dissolved metal and organic pollutants.

In preliminary treatment, the wastewater flows through a coarse screen. The screen removes rocks, sticks, rags, and other large objects that might clog smaller pipes or pumps in the treatment plant. The debris collected on these screens is removed mechanically and disposed of in a landfill. Many plants have comminution devices that grind up large pieces of debris.

After the wastewater has been screened, it passes through a grit chamber, where sand, grit, cinders, and small stones are allowed to settle to the bottom. The grit that settles out is usually removed from the tank, washed, and disposed of in a landfill.

3.1.3 Primary Treatment

With the screening completed and the grit removed, the wastewater still contains suspended solids, some of which can be removed by treatment in a


10
8
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1
3
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6
4
San Francisco
Denver
Kansas City
Chicago
Boston
New York
Philadelphia
Dallas
Atlanta
10
9
2

Regions

4 — Alabama
10 — Alaska
9 — Arizona
6 — Arkansas
9 — California
8 — Colorado
1 — Connecticut
3 — Delaware
3 — D.C.
4 — Florida
4 — Georgia
9 — Hawaii
10 — Idaho
5 — Illinois
5 — Indiana
7 — Iowa
7 — Kansas
4 — Kentucky
6 — Louisiana

Regions

1 — Maine
3 — Maryland
1 — Massachusetts
5 — Michigan
5 — Minnesota
4 — Mississippi
6 — Missouri
8 — Montana
7 — Nebraska
9 — Nevada
1 — New Hampshire
2 — New Jersey
6 — New Mexico
2 — New York
4 — North Carolina
8 — North Dakota
5 — Ohio
6 — Oklahoma
10 — Oregon

Regions

3 — Pennsylvania
1 — Rhode Island
4 — South Carolina
8 — South Dakota
4 — Tennessee
6 — Texas
8 — Utah
1 — Vermont
3 — Virginia
10 — Washington
3 — West Virginia
5 — Wisconsin
8 — Wyoming
9 — American Samoa
9 — Guam
2 — Puerto Rico
2 — Virgin Islands

FIGURE 3-1. EPA Regions

Source: EPA Directory, Winter 1986.

sedimentation tank. This removal is referred to as primary treatment. Wastewater flows very slowly through the tanks so that the suspended solids gradually sink to the bottom. The mass of settled solids (raw primary sludge) is removed from the sedimentation tank by mechanical scrapers and/or pumps.

Floating materials, such as oil and grease, rise to the surface of the sedimentation tanks. They are collected by a mechanical skimmer and removed from the tank for further processing. Primary treatment typically produces 2,500 to 3,500 liters of sludge per million liters of wastewater.[2] Some of this sludge is reused within the plant's treatment system; the remainder is removed for sludge treatment and eventual disposal.

Most wastewater treatment facilities provide primary treatment. This level of treatment is effective in removing certain conventional pollutants present in domestic wastewater, such as biological oxygen demand (BOD) and total suspended solids (TSS). The left-hand column in Table 3-5 provides summary information concerning treatment facilities that provide only primary treatment. Note that at the time of the 1986 Needs Survey, 2,106 facilities (accounting for 16.5 percent of the nation's wastewater flow) provided only primary treatment.

3.1.4 Secondary Treatment

The major purpose of secondary treatment is to remove soluble BOD that escapes primary treatment and to provide further removal of suspended solids that do not settle out during primary treatment. Secondary treatment processes result in average BOD and TSS concentrations of 30 mg/liter each. Secondary treatment is now the minimum treatment level required for municipalities under the Clean Water Act.

Secondary processes are usually biological, i.e., they employ microorganisms (such as bacteria) to digest organic material within the wastewater under conditions in which a supply of oxygen is available. The organisms use the organic impurities in the wastewater as food and in the

TABLE 3-5

LEVEL OF WASTEWATER TREATMENT PROVIDED BY FACILITIES THROUGHOUT THE UNITED STATES

	PRIMARY TREATMENT	SECONDARY TREATMENT	ADVANCED SECONDARY TREATMENT	ADVANCED WASTEWATER TREATMENT	NO DISCHARGE	TOTAL
Number of Facilities	2,106	8,325	2,828	254	1,720	15,233[a]
Percentage of Facilities	13.8	54.7	18.6	1.7	11.3	100.0
Volume of Wastewater Treated (MGD)	4,581	12,141	9,524	840	608	27,694
Percentage of Wastewater (%)	16.5	43.8	34.4	3.0	2.2	100.0

[a] Not all facilities were accounted for in this tabulation.

Source: The 1986 Needs Survey, EPA.

Note: Rows may not add to the total due to rounding.

1509S

process release carbon dioxide and water. The microorganisms and more solids are then removed by sedimentation, and the purified water flows to the next treatment step, or to discharge.

Table 3-5 provides summary data on the treatment facilities providing secondary treatment. The secondary treatment facilities are subdivided in the Needs Survey between secondary treatment and advanced secondary treatment. Secondary treatment provides removal of BOD, TSS, and nutrients (ammonia and phosphorus). Advanced secondary treatment is defined in the Needs Survey to encompass treatment facilities that remove these same pollutants in excess of the amounts removed by conventional secondary treatment systems. For example, a plant is considered to provide advanced secondary treatment if it produces an effluent with a BOD concentration in the range of 24 to 10 mg/liter. Table 3-5 shows that 78 percent of the wastewater flow receives secondary treatment. Conventional treatment systems remove approximately 80 percent of BOD and TSS, and advanced secondary treatment systems remove approximately 90 percent of these pollutants. Biological secondary treatment produces 15,000 to 20,000 liters of sludge per million liters of wastewater processed.[3]

3.1.5 Advanced Treatment

Although secondary treatment processes may remove up to 90 percent of BOD and TSS, they remove only minor quantities of some pollutants, including phosphorus, nitrogen, soluble chemical oxygen demand, and heavy metals. Processes capable of removing such pollutants are termed tertiary wastewater treatment or advanced wastewater treatment (AWT) processes.

Table 3-5 shows the number of facilities and the wastewater flow of advanced treatment facilities. As of 1984, only 1.7 percent of all facilities (processing 3.0 percent of the wastewater) were achieving advanced treatment levels. Combining the secondary and advanced treatment columns in Table 3-5, 75 percent of the treatment plants throughout the country (processing 81.2 percent of the wastewater) are achieving secondary treatment or better.

Advanced treatment also generates additional sludges that need treatment and disposal. For example, the use of chemicals for phosphorus removal can generate another 10,000 liters of sludge for every 1 million liters of wastewater processed.[4] The sludges from primary, secondary, and advanced treatment are removed for sludge treatment as described in Section 3.2.

3.1.6 No Discharge

Some wastewater treatment facilities do not discharge into surface water bodies. Most of these facilities are lagoon systems designed for evaporation and/or infiltration of the wastewater flow. Facilities that dispose of their effluent by recycling, reuse, spray irrigation or other land disposal, or groundwater recharge are also included in this category. Because these plants do not discharge into surface waters, they generally do not provide primary or secondary wastewater treatment and, therefore, do not produce sludge. In 1986, some 1,720 plants (accounting for 2.2 percent of the nation's wastewater) did not discharge effluents into surface water bodies.

3.2 Sludge Treatment

Municipal wastewater sludge is generated at several stages of the wastewater treatment process as described above. Treatment plants condition, thicken, and dewater this sludge to reduce its volume as much as possible. Stabilization techniques are employed to break down organic solids so that sludges are less odorous and putrescible. Stabilization also makes sludge easier to dewater.

The degree of dewatering that takes place depends on the ultimate use or disposal of the sludge. Before dewatering, sludge is typically 3 to 7 percent solids. If sludge is to be incinerated, a drier sludge (greater than 20 percent solids) is desirable. Certain land application techniques (spray or injection) will require a more liquid sludge that can be dispensed easily.

3.2.1 Sludge Conditioning

Sludge conditioning processes are used at wastewater treatment plants to facilitate the separation of the solids from the liquid portion. One of the most commonly used processes is the addition of coagulants, which are used to clump the solids together so that they can be separated more easily from the water. Chemical coagulants, such as ferric chloride, lime, or organic polymers, are added to the sludge prior to the dewatering process. Another sludge conditioning process, heat treatment, consists of heating the sludge to high temperatures, causing liquids bound up in the solids within the sludge to be released.

3.2.2 Thickening

After the sludge has been conditioned, it is often thickened before further processing. There are two principal methods: (1) gravity thickening, and (2) flotation thickening. The goal of both processes is to remove as much water as possible before dewatering. These processes offer low-cost means for reducing sludge volume to one-half or one-third its initial volume.

Gravity thickening is a settling process that has been used on primary sludges for many years. Sludge flows into a tank where solids settle to the bottom and are removed by mechanical scrapers. Gravity thickening is most effective on primary sludges, which can be thickened from 1 to 3 percent solids up to 10 percent solids. If the solids entering a gravity thickening process are principally secondary sludges, then the solids content of the sludge coming out of the process will be lower.

In flotation thickening, air is injected under pressure sufficient to allow it to dissolve. The sludge then flows to an open tank, where much of the air is released from solution as minute air bubbles. These bubbles attach themselves to sludge particles, which then rise to the surface. The sludge forms a layer at the top of the tank that is removed by a skimmer. Flotation thickening is especially effective on secondary sludge that is difficult to separate by gravity. The process can increase the solids content of secondary sludge from 0.5 to 1 percent to 3 to 6 percent.

3.2.3 Stabilization

Sludge stabilization breaks down organic solids so they are less odorous and less putrescible and more easily dewatered. The process also reduces the mass of sludge. Stabilization techniques include anaerobic digestion, aerobic digestion, composting, lime stabilization, chlorine oxidation, and heat treatment.

Anaerobic digestion, which can reduce the solids in sludge by 50 percent, is typically a two-step process. In the first step, anaerobic bacteria break down the organic solids within the sludge, resulting in the formation of methane gas (which can be used as an energy source) and carbon dioxide. The second step concentrates the digested sludge at the bottom of another tank. The relatively clear supernatant is then recycled to the wastewater treatment plant.

Aerobic digestion is accomplished by aerating sludge in an open tank. Aerobic bacteria digest the organic matter in sludge, thus reducing its mass, odor, and putrescibility. Aerobic digestion is used most extensively in small treatment plants. This process can also achieve the same 50 percent reduction in solids.

Composting uses aerobic or anaerobic bacteria in a static or aerated pile of sludge that is mixed with bulking agents. This technique is often used in conjunction with the distribution and marketing of sludge.

Lime stabilization involves the addition of lime to sludge, which raises the pH to a level sufficient to reduce pathogenic microorganisms and prevent putrefaction. Lime does not destroy the organics necessary for bacterial growth; therefore, the pH must be maintained to prevent reinfestation. The addition of lime also facilitates dewatering.

Chlorine oxidation involves exposing sludge to chlorine gas for a short time in a reactor. This process kills harmful microorganisms and prepares the sludge for dewatering.

In heat treatment sludge is heated in a pressure vessel to 500°F. This process stabilizes and conditions sludge for dewatering without the use of chemicals.

3.2.4 Dewatering

The final step in the sludge treatment process is dewatering. Dewatering removes sufficient water from the sludge to allow its ultimate transportation and disposal. A number of dewatering processes are used, including air drying, vacuum filtering, centrifuges and belt filter pressing.

Air drying is a common process in which sludge is placed on a sandbed and allowed to dry through a combination of drainage and evaporation. Sandbeds can achieve solids content in primary sludge of 45 percent to 90 percent and are relatively simple to operate. Such systems, however, have large space requirements, and larger municipalities rely more heavily on mechanical dewatering systems, such as vacuum filters, centrifuges, and belt filter presses.

A vacuum filter system consists of a cylindrical drum covered with a filter material. The drum rotates while submerged in a vat of conditioned sludge. A vacuum is applied from within the drum, drawing water into the drum and leaving the solids or "filter-cake" on the outer filter medium. As the drum rotates, the dewatered sludge is scraped off the filter medium for eventual disposal. Vacuum filtering is the most popular mechanical drying process and typically achieves a 30 to 40 percent solids content with primary sludges.

Centrifuges achieve drying by spinning digested sludge in a horizontal, cylindrical vessel at high speeds. The solids concentrate on the outside of the vessel and are scraped off and removed for disposal. Centrifuges can achieve solids contents comparable to those of vacuum filters.

Belt filter presses dewater sludge by pumping it at high pressure through a filter medium. The pressure forces water out of the sludge, and the dried sludge cake is retained on the filter. Pressure filtration offers the advantage of providing the driest sludge cake of the mechanical dewatering methods (e.g., 50 percent solids with primary sludges), but the method is more expensive than vacuum filtration or centrifugation.

The Needs Survey provides information concerning the sludge thickening, stabilization, and dewatering processes employed throughout the country. A summary of these data is presented in Table 3-6.

3.3 Sludge Use and Disposal

After municipal wastewater sludge has been treated, it is usually either disposed of or used as a soil conditioner. The use/disposal method selected by a municipality depends on a variety of factors, such as the cost of preparing the sludge for each option; the disposal cost; contaminant levels in the sludge; availability of markets for sludge products; transportation costs to markets or disposal sites; availability of suitable sites for land application or landfilling; state environmental regulations; and public acceptance. Many treatment facilities use more than one disposal method due to capacity limitations of any single option.

Six major sludge use/disposal options are used predominantly:

- Incineration
- Ocean Disposal
- Landfilling
- Surface Impoundments
- Land Application
- Distribution and Marketing

TABLE 3-6

SLUDGE TREATMENT PROCESSES IN USE

TREATMENT STEP	TYPE OF PROCESS	NUMBER OF FACILITIES EMPLOYING PROCESSES	PERCENT OF TOTAL OF FACILITIES	FLOW PROCESSED BY FACILITIES EMPLOYING PROCESS (MGD)	PERCENT OF TOTAL FLOW (%)
Thickening	Gravity Thickening	1,106	7.2	10,194	36.8
	Air Flotation Thickening	369	2.4	5,752	20.7
Stabilization	Anaerobic Digestion	3,980	26.0	18,319	66.1
	Aerobic Digestion	4,028	26.3	5,223	18.8
	Heat Treatment	164	1.1	3,325	12.0
	Chlorine Oxidation	44	0.3	308	1.1
	Lime Stabilization	106	0.7	796	2.9
Dewatering	Air Drying	6,583	43.0	9,448	34.1
	Vacuum Filter	1,275	8.3	10,949	39.5
	Centrifuge	318	2.1	5,009	18.1
	Filter Press	457	3.0	3,657	13.2
National Total		15,305[a]	–	27,726[a]	-

[a] Numbers in columns do not add to national totals because some facilities did not respond in these categories and other facilities responded in more than one category.

Source: The 1986 Needs Survey, EPA.

1510S

Ocean disposal has, however, recently been banned, so this disposal method is not covered by the proposed regulations. The POTWs currently using ocean disposal are expected to shift to other disposal methods in the near future.

3.3.1 Incineration

Incineration is the burning of volatile materials in sludge in the presence of oxygen. The residue of the combustion process (ash) is generally disposed of as a solid waste. Incineration reduces the solids in sludge to 20 percent of the original volume, thereby greatly reducing the volume of the material requiring disposal. Incineration also destroys pathogens and some toxic organic chemicals in the sludge. Incinerators commonly used for sludge are of four major designs: multiple hearth, fluid bed, rotary kiln, and electric furnaces. These incinerator designs are described in Section 4.1 of this report.

3.3.2 Ocean Disposal

Ocean disposal is the release of sludge into a designated area of the ocean, either from a vessel or from an ocean outfall pipe. All types of ocean disposal have been banned, and this activity must cease within the next few years. At present, a number of municipalities in the New York/New Jersey area barge sludge to an ocean dump site; Los Angeles, California, and Boston, Massachusetts, discharge their sludges into the ocean through an outfall. All of these POTWs must shift to other disposal methods.

3.3.3 Surface Impoundments

Surface impoundments, also called lagoons, are earthern pits into which sludge is discharged. They are used to treat, dewater, and dispose of sludge. Only those lagoons in which sludge is stored for more than one year or ultimately disposed are covered by the proposed regulations.

For treatment, sludge is discharged into a lagoon. Stabilization takes places through aerobic or anaerobic digestion. Some lagoons are aerated to promote aerobic biodegradation. Stabilized solids settle to the bottom of the lagoon and the supernatant is drawn off and returned to the plant for further treatment.

Lagoons are also used for dewatering. Treated or untreated sludge is left in the lagoon for long periods of time to dry through evaporation. These drying lagoons are typically located in areas of net evaporation (mostly west of the Mississippi). Although lagoons are meant for treatment or dewatering, settled sludge solids may be left in the lagoon indefinately as more sludge is added over the years. When sludge solids fill the lagoon to capacity, one of two things are done. The lagoon is dredged and the solids taken to a landfill or it is covered with soil and closed. As long as wastewater is being separated from the sludge, this type of lagoon would be considered a treatment lagoon. When the lagoon has been inactive for more than a year, it comes under coverage of the proposed regulations.

3.3.4 Landfilling

Sludge can be disposed of in landfills alone or mixed with other solid waste and buried beneath a soil cover. Once buried, the sludge gradually degrades. The proposed criteria regulate landfills that dispose of municipal wastewater sludge only (i.e., sludge-only landfills, sometimes called monofills) and landfills that dispose of both solid waste and sludge (referred to as codisposal). The proposed requirements for the codisposal of sludge reference Subtitle D regulations under RCRA. No separate mandates are proposed for these landfills under this rulemaking. Thus, only the monofilling of sludge is discussed in this report.

There are two basic methods of monofilling sewage sludge: trenching and area filling.[5] Trenching is used in cases where the ground water and bedrock are deep enough to allow a sufficient buffer from the bottom of the trench. Sludge is deposited into the trench, usually from a haul vehicle.

Soil for top cover is obtained from the excavation of the trench. This method of landfilling is appropriate for unstabilized or mildly stabilized sludges because odors are controlled by the application of top cover. The top cover is generally 2 to 4 feet thick, depending on the width of the trench, which may vary substantially.

Narrow trenches are used when sludge solids content is low (15 to 28 percent solids). Very low solids sludge (15 to 20 percent) would not support soil cover in a trench greater than 2 to 3 feet in width. Closely spaced sidewalls are needed to provide enough support to prevent the soil layer from sinking into the sludge. Sludge with a higher solids content (20 to 28 percent) can support soil cover in a wider trench (3 to 10 feet wide). At this solids content, however, sludge cannot support heavy equipment, so soil must be dropped in from either side of the trench. Trenches wider than 10 feet must have sludge with a solids content of 28 percent or greater in order to support equipment for spreading top cover.

In area fills, sludge is deposited on top of the surface soil in a specific area. This method of landfilling is preferable where the ground water or bedrock is shallow. Generally, a bulking agent such as soil is added to the sludge to improve sludge stability and bearing capacity so heavy equipment can be supported. Stabilized sludges are more suitable to area fills because sludges are not always covered immediately with top soil.

Three area filling techniques are currently used: (1) area fill mound; (2) area fill layer; and (3) diked containment. The first technique involves the mixing of soil with sludge to obtain a material with greater bearing capacity and stability. Sludge with a solids content of at least 20 percent is appropriate for this method. The sludge and soil mixture is stacked into mounds about 6 feet high. Cover material, a minimum of 3 feet thick, is applied on top of the mounds. Five feet of cover is applied if a second mounding of sludge is made at a later date.

Area fill layering can utilize a slightly wetter sludge (as low as 15 percent solids). With this method, sludge is mixed with a bulking agent and then spread in even layers of 0.5 to 3 feet in thickness. Additional cover may be added between sludge layers, and a final top cover is laid 2 to 4 feet thick.

A diked containment involves the construction of dike walls on top of the original ground surface. Sludge is dumped into the diked containment from a vehicle access at the top of the dike. Interim cover can be applied between fillings, and a final cover is applied once filling is complete. Solids content for this disposal method should be greater than 20 percent.

3.3.5 Land Application and Distribution and Marketing

Land application is typically defined as the spreading of sludge on or just below the surface of the land. Distribution and marketing is a subset of land application under this definition. The proposed regulation, however, includes different requirements for distribution and marketing than for other forms of land application. Land-applied sludge is usually incorporated into the soil after application to minimize odors, runoff, or contact with animals and humans. The sludge can serve as a soil conditioner and as a partial replacement for commercial fertilizers. Sludge is applied on agricultural lands; forest lands; drastically disturbed lands (land reclamation) or land dedicated specifically to sludge disposal (dedicated land disposal); parklands; golf courses; or home gardens and lawns. Table 3-7 lists the potential end uses of land-applied sludge.

Sludge is applied to the land in liquid or dewatered form. Liquid sludges are transported to the application site in tank trucks and sprayed on or injected into the soil. Dewatered sludges (filtered cakes) can be applied to the land with spreading equipment. Sludge is applied to dedicated sites (where it is applied to the soil in periodic repeated applications) at a higher rate than to agricultural lands or lands used for other purposes.

Sludge can also be composted or heat-dried before being applied on land. In composting, sludge is dewatered and mixed with a bulking agent (e.g., wood chips) and allowed to decompose anaerobically or aerobically for a period of time. Decomposition produces a humus-like product resembling soil. Sludges can also be heat-dried to remove water and destroy all pathogens. The dried end product of this process can also be used as a soil conditioner. Composted or heat-dried sludges may be bagged or shipped in bulk to their end use. These products are sold or given away to end users (distribution and

TABLE 3-7

LAND APPLICATION END USES

Land Application

- Agricultural use
- Silviculture
- Land reclamation
- Dedicated land

Distribution and Marketing

- Home gardens
- Lawns (residential)
- Landscaping (ornamental)
- Nurseries-pot (ornamental)
- Nurseries-pot (food-chain plants)
- Nurseries-field (food-chain plants)
- Nurseries-field (ornamental)
- Turf farms
- Golf courses
- Park and recreational areas
- Cemeteries
- Highway landscaping
- School grounds
- Other public lands

1511S

marketing). Further processing beyond the composting step may also occur. For example, additives may be incorporated to raise the nutrient levels in the sludge product. In this way, the nutrient levels in the sludge product can be made to resemble those in commercial fertilizers.

Concurrent with improving soil productivity, land application also functions as a sludge treatment system. Sunlight, soil microorganisms, and desiccation can destroy many pathogens and organic substances in the sludge. Nutrients, which can cause eutrophication and other problems if released into surface waters, are largely converted into useful biomass, such as crops or wood. The capacity of the land to treat sludge constituents is finite, however, and land application systems must be designed and managed to work within the assimilative capacity of the land and the crops grown on it.

3.4 National Distribution of Sludge Use and Disposal Methods

This section provides estimates of the national distribution of sludge use and disposal methods among POTWs. These estimates were developed using original research and existing data sources. Estimates of the associated volume of wastewater treated and sludge generated by POTWs for each disposal method are also provided.

For analytical purposes a simplifying assumption was made. Each plant was assumed to practice only one disposal method. In actuality, many POTWs use several methods of sludge disposal. It is not clear what effect this assumption has on the analysis, but no major bias is anticipated in the amount of sludge being disposed using each disposal method nor in the economic impact assessment.

3.4.1 Incineration

Approximately 21 percent of the municipal wastewater sludge produced in the United States is incinerated. Currently, 169 POTWs have one or more incineration units on site to burn sewage sludge (see Table 3-8). Many POTWs maintain more than one unit, either for backup purposes or to meet capacity needs. Approximately 282 incineration units currently operate.

Several data sources were used to develop the list of POTWs currently incinerating sludge and the total number of incineration units (Table 3-8). The starting point was a list of 132 incineration facilities compiled in a recent EPA study conducted by Radian.[6] In most cases, this list did not provide the name of the treatment plant itself, but rather the location. It did, however, provide the number of incineration units at each location. Each site was then matched with the proper treatment plant name using the 1986 Needs Survey. Telephone verifications for many facilities were made.

Second, a computer search of the Needs Survey was performed to identify any facilities not on the Radian list that reported incinerator use to EPA. The Needs Survey reported 353 POTWs with incinerators. The verification checks of these facilities revealed, however, that many of these POTWs either had no incinerator or had an incinerator that was no longer in use.

As a final step, the list of incineration facilities developed from the Needs Survey and the Radian Report was subjected to the following additional reviews:

- The list was compared to another list published in the EPA Technology Transfer document on Sewage Sludge Incineration.[7]
- The list was compared to information on incinerator locations available from equipment suppliers.

Following all these reviews, the list of 169 POTWs and 282 operating units shown in Table 3-8 was compiled.

The majority of incineration units in the United States are multiple hearth, accounting for 78 to 82 percent of the total units in operation (see Tables 3-9 and 3-10). Fluid bed incinerators are the second most common design, accounting for approximately 9 to 13 percent of all incineration units.

TABLE 3-8

INCINERATORS CURRENTLY IN OPERATION IN THE U.S.

NAME	CITY, STATE	TYPE	# OF UNITS	TOTAL CAPACITY (DRY MTPD)
Point Woronzof	Anchorage, AK	1	1	22.9
Wrangell	Wrangell, AK	3	1	0.2
Barstow Regional WWTF	Barstow, CA	2	1	2.3
Lake Arrowhead	Lake Arrowhead, CA	1	1	4.4
S. Lake Tahoe	Lake Tahoe, CA	1	1	0.7
Palo Alto	Palo Alto, CA	1	2	5.5
S. Bayside WWTP	Redwood City, CA	2	1	13.6
Sacto Regional WWTF	Sacramento, CA	1	1	6.5
San Clemente WWTF	San Clemente, CA	1	1	11.4
San Mateo	San Mateo, CA	1	1	4.5
Central Contra Costa	Walnut Creek, CA	1	2	40
Mattabassett	Cromwell, CT	1	1	11.4
Hartford	Hartford, CT	1	3	305
Naugatuck WPCF	Naugatuck, CT	1	2	45
New Canaan	New Canaan, CT	4	1	35.4
East Shore	New Haven, CT	1	1	26.5
New London	New London, CT	1	2	47.1
Norwalk	Norwalk, CT	2	1	33
Vernon WPCF	Rockville, CT	1	1	12.4
Stamford	Stamford, CT	4	1	86
Waterbury	Waterbury, CT	1	1	5.9
Main Street STP	Pensacola, FL	1	2	36
RM Clayton WPCP (Bolton Rd.)	Atlanta, GA	1	2	117.8
Utoy Creek WWTP	Atlanta, GA	1	1	7.4
Snapfinger Creek STP	Decatur, GA	3	1	40.7
Flat Creek WPCP	Gainesville, GA	3	2	5.0
Chattahoochee WWTF	Marietta, GA	1	1	18.0
President Street WPCP	Savannah, GA	1	2	11
Sand Island	Honolulu, HI	1	2	23.5
Honouliuli WWTF	Honolulu, HI	1	1	
Cedar Rapids	Cedar Rapids, IA	1	1	22.1
Davenport	Davenport, IA	1	1	32.4
Dubuque	Dubuque, IA	2	2	6.8
Indianapolis (Belmont)	Indianapolis, IN	1	6	329.9
KCK WWTP #1 - Kaw Point	Kansas City, KA	2	2	5.8
KCK WWTP - Plant #20	Kansas City, KA	2	1+	--
Mission Township Main SD#1	Shawnee Mission, KA	1	1	--
Turkey Creek	Shawnee Mission KA	1	1	16.2
New Orleans West Bank	New Orleans, LA	1	1	14.7

TABLE 3-8 (CONT.)

NAME	CITY, STATE	TYPE	# OF UNITS	TOTAL CAPACITY (DRY MTPD)
New Orleans East Bank	New Orleans, LA	2	1	37
Lake Charles	Lake Charles, LA	1	1	--
Lake Charles	Lake Charles, LA	1	1	--
Chicopee	Chicopee, MA	1	1	8.7
Fall River STP	Fall River, MA	1	1	41
Fitchburg	Fitchburg, MA	1	1	35.4
New Bedford	New Bedford, MA	1	1	14.7
Greater Lawrence SD WWTP	N. Andover, MA	1	2	82.5
Upper Blackstone Reg. WWTP	Worcester, MA	1	3	159
Patapsco WWTP	Baltimore, MD	1	3	89.5
Ocean City	Ocean City, MD	2	1	6.5
Western Branch WWTP	Upper Marlboro, MD	1	2+	--
Ann Arbor	Ann Arbor, MI	1	1	49
Bay City	Bay City, MI	1	1	2.9
Detroit STP	Detroit, MI	1	14	436
Wyandotte WWTP	Wyandotte, MI	1	4	222.1
East Lansing	East Lansing, MI	1	2	29.5
Flint WPCF	Flint, MI	1	4	--
Grand Rapids	Grand Rapids, MI	1	1	29.5
Kalamazoo	Kalamazoo, MI	1	1	44
Lansing WWTP	Lansing, MI	1	1	44
Pontiac	Pontiac, MI	1	1	58.9
Port Huron	Port Huron, MI	2	1	6.9
Trenton WWTP	Trenton, MI	1	1	65
Warren	Warren, MI	1	1	23.5
Ypsilanti Community WWTP	Ann Arbor, MI	1	1	49
WLSSD Regional WWTP	Duluth, MN	4	2	31
Seneca	St. Paul, MN	1	2	17.6
Metropolitan	St. Paul, MN	1	6	706.9
Rock Creek WWTP	Independence, MO	2	1	8.8
Big Blue River STP	Kansas City, MO	1	1	41.2
St. Louis (Lemay)	St. Louis, MO	1	4	132.5
St. Louis (Bissell Pt)	St. Louis, MO	1	5	294.5
Papillion Creek WWTP	Omaha, NB	2	1+	--
N. Buffalo WTP	Greensboro, NC	1	1	41.3
Rocky Mount	Rocky Mount, NC	1	1	6.8
Shelby	Shelby, NC	2	1	14.7
Manchester WWTP	Manchester, NH	1	2	--
Lebanon	Lebanon, NH	1	1	6.5
Round Hill (Douglas County SID #1 WWTP)	Lake Tahoe, NV	2	1	4.1

TABLE 3-8 (CONT.)

NAME	CITY, STATE	TYPE	# OF UNITS	TOTAL CAPACITY (DRY MTPD)
Atlantic City Reg. STP	Atlantic City, NJ	1	1	21.8
Wayne (Mt. View)	Wayne, NJ	1	2	87
Parsippany-Troy Hills TP	Parsippany, NJ	1	2	70.7
Pequannock-Fairfield STP	Pequannock-Lincoln Park, NJ	2	1	--
Stony Brook TP #1 (River Rd.)	Princeton, NJ	1	2	35.9
Summerset-Raritan	Raritan, NJ	1	1	10.9
Bayshore Regional STP	Union Beach NJ	2	1	27
Waldwick (N.W. Bergen Co.)	Waldwick, NJ	1	1	16
North Albany STP	Menands, NY	1	2	117.8
South Albany STP	Albany, NY	1	2	83.5
Auburn STP	Auburn, NY	1	1	36.8
Southwest SD #3	Babylon, NY	1	2	136
Beacon	Beacon, NY	1	1	8.8
Bird Island	Buffalo, NY	1	3	166.9
Dunkirk STP	Dunkirk, NY	1	1+	--
Erie County SD #3, Southtowns	Hamburg, NY	2	2	262
Glen Cove	Glen Cove, NY	4	1	23
Little Falls	Little Falls, NY	2	1	3.5
Saratoga County SD #1	Mechanicville, NY	2	1	31.6
New Windsor STP	New Windsor, NY	2	1	--
New Rochelle STP	New Rochelle, NY	1	2	33
Oneida County WPCP	Utica, NY	2	2	36
Orangetown	Orangetown, NY	1	1	15.3
Ossining San. Sew. Dis.	Ossining, NY	1	2	18.8
Oswego West Side STP	Oswego, NY	1	1	11.4
Oswego East Side STP	Oswego, NY	1	2	27.3
Port Chester SD STP	Port Chester, NY	1	1+	--
Port Washington STP	Port Washington, NY	2	1	9
Arlington	Poughkeepsie, NY	2	1	7.6
NW Quadrant TP	Greece, NY	1	2	44
Frank E. Van Lare STP	Rochester, NY	1	2	65
Gates Chili Ogden STP	Rochester, NY	1	2	33
Schenectady STP	Schenectady, NY	1	1	127
Field Memorial WPCP	Watertown, NY	2	1	19
Akron	Akron, OH	1	2	17.6
Canton	Canton, OH	1	2	23
Muddy Creek WWTP	Cincinnati, OH	1	1	--
Cincinnati (Mill Creek)	Cincinnati, OH	1	4	153.1
Westerly WWTP	Cleveland, OH	1	2	176.7
Southerly WWTP	Cleveland, OH	1	4	235.6
Columbus-Southerly WWTP	Columbus, OH	1	2	41.3

TABLE 3-8 (CONT.)

NAME	CITY, STATE	TYPE	# OF UNITS	TOTAL CAPACITY (DRY MTPD)
Columbus (Jackson Pk)	Columbus, OH	1	1	35.4
Euclid	Euclid, OH	1	2	19.6
Meander Creek STP	Mineral Ridge, OH	1	1	9
Willoughby Eastlake STP	Willoughby, OH	1	1	22
Youngstown	Youngstown, OH	1	1	36.8
Durham Regional STP	Tigard, OR	1	2	14
Alcosan WWTP	Alcosan, PA	*	3	172
Kiski Valley	Appolo, PA	1	6	123.7
Delora-Chester	Chester, PA	1	2	17.6
Hatfield Township	Colmar, PA	1	1	5.1
Lower Lackawanna STP	Duryea, PA	1	1	23.5
Erie City STP	Erie, PA	1	1+	123
Johnstown	Johnstown, PA	1	1	7.4
Harrisburg	Harrisburg, PA	4	2	123.1
Greater Hazleton Joint SA	Hazleton, PA	2	1	4.1
Derry Township WPCP	Hershey, PA	1	1	36.8
Upper Gwynedd	N. Wales, PA	2	1	1.0
E. Norriston Plymouth T.P.	Norristown, PA	1	1	109
Tyrone Borough STP	Tyrone, PA	2	1	4.6
Upper Moreland-Hatboro T.P.	Willow Grove, PA	1	1	8.7
Wyoming Valley	Wilkes-Barre, PA	1	1	29.5
York	York, PA	1	2	35.3
Cranston WPCP	Cranston, RI	1	2	18.5
Plum Island TP	Charleston, SC	1	1	29.5
Metropolitan TP	Columbia, SC	1	2	7.5
Galloway Mill Plant	Bristol, TN	1	1	14.7
Clarksville Main WWTP	Clarksville, TN	2	1+	--
Maryville Regional STP	Maryville, TN	1	1	12
Nashville Central WWTP	Nashville, TN	1	4	91
Newport	Newport, TN	1	1	7.1
Quail Valley STP	Missouri City, TX	3	1+	--
Arlington County WPCP	Arlington, VA	1	2	31.6
Lower Straubles Creek STP	Blacksburg, VA	2	2+	22.1
Lower Potomac	Fairfax, VA	1	2	82.5
Hopewell	Hopewell, VA	1	1	7.4
Boat Harbor	Newport News, VA	1	2	8.9
Army Base WPCP	Norfolk, VA	1	2	23.2
Lamberts Point WPCP	Norfolk, VA	1	2	39.1
Chesapeake-Elizabeth WPCP	Virginia Beach, VA	1	2	--
Williamsburg	Williamsburg, VA	1	2	4.8
Mooney STP	Woodbridge, VA	1	1	26.2
Bellingham Poll. Cntl. Plant	Bellingham, WA	1	1	--

TABLE 3-8 (CONT.)

NAME	CITY, STATE	TYPE	# OF UNITS	TOTAL CAPACITY (DRY MTPD)
Edmonds	Edmonds, WA	2	2+	1.5
Lynnwood	Lynnwood, WA	2	2+	0.6
Vancouver Westside STP	Vancouver, WA	1	1	31
Brookfield	Brookfield, WI	1	1	3.5
Depere WWTP	Depere, WI	1	1	31.6
Green Bay	Green Bay, WI	1	2	79.5
Clarksburg STP	Clarksburg, WV	1	1+	--

*One unit is a multiple hearth, the other two are flash combustion units.

+The number of units has not been verified in this case.

Type Key:
1 = Multiple Hearth
2 = Fluidized Bed
3 = Electric
4 = Refuse/Sludge
5 = Other

Source: Radian Corporation, Municipal Waste Combustion Study, Data Gathering Phase, October 1985; EPA, Municipal Wastewater Sludge Combustion Technology, Technology Transfer, September 1985; and ERG research efforts.

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TABLE 3-9

DISTRIBUTION OF INCINERATOR TYPES BASED ON RADIAN SURVEY AND ERG SOURCES

TYPE	NUMBER OF UNITS	PERCENT OF TOTAL
Multiple Hearth	231	82
Fluidized Bed	37	13
Electric	5	2
Refuse/Sludge	7	2
Other	2	1
TOTAL UNITS	282	100
TOTAL POTWs	169	

Source: Radian Corporation, Municipal Waste Combustion Study and ERG research efforts.

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TABLE 3-10

DISTRIBUTION OF INCINERATOR TYPES BASED ON 1986 NEEDS SURVEY

INCINERATOR TYPES	NUMBER OF POTWs	PERCENT OF TOTAL
Multiple Hearth	314	78.3
Fluid Bed	34	8.5
Rotary Kiln	7	1.7
Pyrolysis	5	1.2
Co-incineration with Solid Waste	11	2.7
Co-pyrolysis with Solid Waste	11	2.7
Other Incineration	19	4.7
TOTAL	401	100.0

Source: The 1986 Needs Survey, EPA.

Note: These data were available for POTWs reporting incinerators to EPA in the Needs Survey. Thus, these data do not reflect the list of incinerator units identified by ERG.

All sewage sludge incinerators in the United States currently have some type of wet scrubber to control particulate emissions. The most common device used is the venturi scrubber with impingement plate aftercooler (see Table 3-11).

Sewage sludge incinerators are concentrated on the East Coast, the Midwest, and the West Coast of the United States (see Figure 3-2). POTWs in New York, Pennsylvania, Ohio, and Michigan account for almost 45 percent of the incineration units in the country.

3.4.2 Ocean Disposal

Three EPA regions have been allowing ocean disposal of sewage sludge. In Region IX, Los Angeles disposes of sludge through an ocean outfall pipe. Two Boston-area sewage treatment plants in Region I release sludge through an outlet to the outgoing tides. Region II, which includes New York and New Jersey, is the only region where barging of sewage sludge to an ocean dumping site is taking place.

A Consent Decree ordered Los Angeles to cease the discharge of sludge through the ocean outfall by July 1, 1985. The cessation order has been renegotiated and an extension granted, however, since the construction of the new sludge disposal plant, the Hyperion Energy Recovery System, has taken more time than originally anticipated. Since the phasing out of ocean disposal in this region is imminent, this analysis will not include Los Angeles as one of the municipalities potentially affected by the ocean disposal criteria.

The Boston-area sewage treatment plants are also under court order at this time. Boston cannot continue to use the ocean outfall for sludge disposal. In October 1985, a new sewerage authority, the Massachusetts Water Resources Authority (MWRA), was formed to operate the sewage system and establish an interim and long-term sludge disposal plan. At present, the authority is awaiting bids from several firms regarding sludge disposal services for the interim period. A long-term sludge disposal plan is currently being formulated.

TABLE 3-11

DISTRIBUTION OF POLLUTION CONTROL DEVICES

TYPE OF DEVICE	NUMBER OF UNITS	PERCENT OF TOTAL
Impingement	39	17.3
Venturi	28	12.4
Venturi/Impingement	57	25.3
Wet Cyclone	16	7.1
Spray Chamber	2	0.8
ESP - (Coincinerators)	4	1.7
Wet Cyclone/Impingement	1	0.4
Packed Tower	2	0.8
Unknown	71	31.6
Venturi/Packed Tower	2	0.8
None	3	1.3
Total	225	100

Source: Radian Corporation, Municipal Waste Combustion Study, Data Gathering Phase, October 1986.

Note: These data were available for the incineration units reported by Radian Corp. only. Therefore, these data do not reflect the complete list indentified by ERG.

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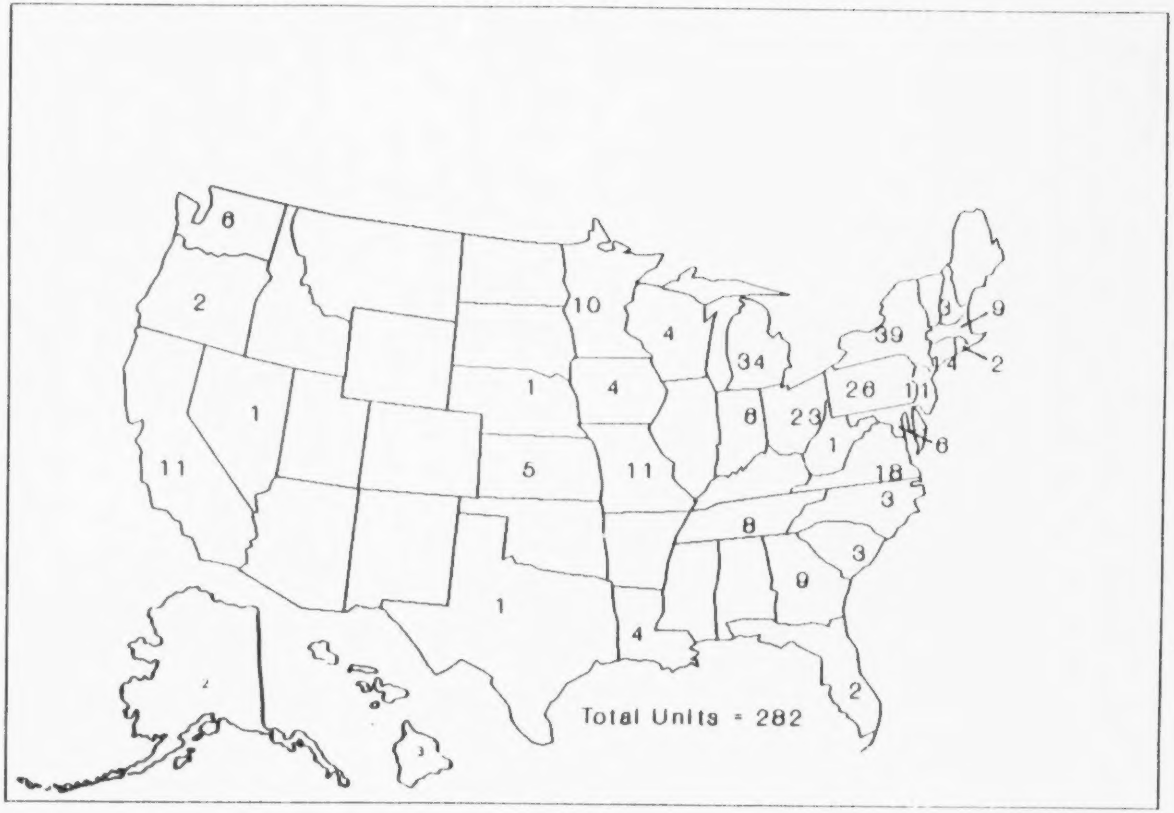

6
2
11
1
1
5
1
10
4
4
11
4
4
34
8
23
8
26
39
3
9
14
2
11
1
6
18
3
3
9
2
Total Units = 282

FIGURE 3-2. Geographic Distribution of Municipal Sewage Sludge Incineration Units

TABLE 3-12

VOLUME OF SEWAGE SLUDGE DISPOSED OF IN THE OCEAN

POTWs OCEAN DUMPING	DESIGN CAPACITY (MGD)	SLUDGE VOLUME IN 1987 (MILLION WET METRIC TONS)
New York City		
Jamaica	NA	3.5
Wards Island	250	
Hunts Point	200	
26th Ward	85	
Coney Island	110	
Owls Head	160	
Newton Creek	310	
Tallmans Island	80	
Bowery Bay	150	
Rockaway	45	
Port Richmond	60	
Nassau County		
Bay Park	60	0.7
Cedar Creek	45	
Inwood	2.5	
Belgrave		
Roslyn	0.5	
West Long Beach	1.5	
Long Beach	6.36	
Westchester County	92	0.4
New Jersey		
Passaic Valley	300	1.1
Bergen County	75	0.6
Linden/Roselle	15	0.08
Rahway Valley	35	0.09
Joint Meeting	75	0.2
Middlesex County	110	0.9
Total	2,268	7.66

Source: Frank Csulak, EPA Region II, April, 1988.

Note: Totals may not add due to rounding.

New York and New Jersey municipalities have been dumping sludge at the 12-Mile Site for many years and more recently, at the 106-mile site. All ocean disposal activity - both ocean dumping and ocean discharge - has been banned, however, and all types of ocean disposal must cease by 1992. Only the New York/New Jersey POTWs that currently use ocean dumping are considered affected by proposed regulations. It is assumed that these POTWs will incinerate their sludge in response to the ocean ban legislation. It is by no means certain that all these POTWs will incinerate their sludge; at the moment, however, incineration is one of the likeliest alternatives for the majority of these POTWs. The number and types of incinerators expected to be constructed by these POTWs are discussed in Section Four of this report.

Volume of Sludge

There are 11 POTWs in New York City, 7 POTWs in Nassau County, 1 POTW in Westchester County, and 6 authorities in New Jersey that use ocean dumping as a sludge disposal method. Table 3-12 lists these POTWs and provides the design capacity of each one. According to EPA Region II, the total quantity of sludge actually dumped in 1987 was 7.7 million wet metric tons.

3.4.3 Distribution and Marketing

Distribution and marketing (D&M) is typically defined as the giveaway or sale of sludge that has been stabilized through composting or heat-drying. EPA compiled a list of POTWs using composting and the volume of sludge composted by each (see Table 3-13).

TABLE 3-13

QUANTITIES OF SLUDGE COMPOSTED ANNUALLY BY FACILITY AND BY STATE (IN DRY METRIC TONS)

STATE AND FACILITY	QUANTITY OF COMPOST PER FACILITY (DMT/YR)	QUANTITY OF COMPOST STATEWIDE (DMT/YR)
Alabama		1,327
Little Choctawhatchee	1,327	
Arizona		3,318
Phoenix	3,318	
California		45,210
Los Angeles County Joint WPCP	17,255	
Los Alisos	83	
Oakland	21,236	
San Francisco	3,318	
Hayward	3,318	
Chino Basin #1 and #2	NA	
Colorado		23,260
Denver	23,227	
Wheatridge	33	
Connecticut		3,764
Greenwich	446	
Bristol	3,318	
Delaware		23,625
Seaford	232	
Wilmington	23,227	
Middletown/Odessa	166	
Florida		7,363-8,690
Broward County (Hollywood)	2,631	
Kissimmee	NA	
Jacksonville	750	
Plant City	1,991	
Martin Street	NA	
Fernandina Beach	NA	
Sarasota	1,991-3,318	
Georgia		531
Northeast Clayton County	531	

TABLE 3-13 (continued)

STATE AND FACILITY	QUANTITY OF COMPOST PER FACILITY (DMT/YR)	QUANTITY OF COMPOST STATEWIDE (DMT/YR)
Hawaii		83
Waimanalo (Honolulu)	83	
Indiana		3,378
Bloomington	3,182	
Crawfordsville	196	
Iowa		709
Ft. Madison	709	
Kansas		7,466
North Topeka	830	
Oakland	3,318	
Wichita	3,318	
Kentucky		1,494-1,659
Hickman West	1,494-1,659	
Maryland		32,422-32,753
Cambridge	964	
Montgomery County Site (Blue Plains)	13,273	
Elkton	664	
Perryville	830	
Black River	16,027	
Havre de Grace	664-995	
Maine		11,707
Bangor	1,785	
Bar Harbor	332	
Gardiner	332	
Kennebunk	45	
Kittery	32	
Old Orchard Beach	2,940	
Old Town	415	
Portland	5,375	
Scarborough	249	
South Portland	3	
Yarmouth	199	

TABLE 3-13 (continued)

STATE AND FACILITY	QUANTITY OF COMPOST PER FACILITY (DMT/YR)	QUANTITY OF COMPOST STATEWIDE (DMT/YR)
Massachusetts		11,448
Swampscott	66	
Hoosac	7,821	
Concord	NA	
Southbridge	1,173	
Leicester	66	
Westborough	1,327	
Mansfield	995	
Michigan		27
Mackinac Island	27	
Minnesota		33-45
Pine River	33-45	
Montana		1,659
Missoula	1,659	
Nebraska		3,567-4,562
Beatrice	498	
Grand Island	2,323-3,318	
Kearney	746	
New Hampshire		10,337-10,479
Durham	654	
Merrimack	6,968	
Plymouth	166	
Claremont	2,124	
Keene	425-567	
New Jersey		11,016
Cape May County	6,636	
Middletown	896	
Buena Borough	1,161	
Pennsville	NA	
Newton (Sussex County MUA)	2,323	
Manville	NA	

TABLE 3-13 (continued)

STATE AND FACILITY	QUANTITY OF COMPOST PER FACILITY (DMT/YR)	QUANTITY OF COMPOST STATEWIDE (DMT/YR)
New York		9,291
Endicott	664	
Guilderland (Nott Road)	332	
Plattsburg	8,295	
East Oneida Lake (Sylvan Beach)	NA	
Alden	NA	
North Carolina		1,826
Morganton (Catawba River)	1,494	
Valdese (Lake Rhodiss PCP)	332	
Ohio		2,323
Lake County (Greater Mentor SD)	2,323	
Oregon		21,070
Portland	19,909	
Newberg	1,161	
Pennsylvania		106,655-107,959
Philadelphia (Northeast, Southeast, and Southwest)	99,545	
Scranton	4,314	
Lancaster	1,303-2,607	
Springettsbury	1,493	
Rhode Island		1,058-1,722
West Warwick	995-1,659	
Jamestown	63	
South Carolina		1,718-2,050
East Richland	1,327-1,659	
Myrtle Beach	391	
Tennessee		1,659-1,991
Dry Creek	1,659-1,991	

TABLE 3-13 (continued)

STATE AND FACILITY	QUANTITY OF COMPOST PER FACILITY (DMT/YR)	QUANTITY OF COMPOST STATEWIDE (DMT/YR)
Texas		1,858
El Paso (Haskel and Socorro)	1,858	
Fredericksburg	NA	
Almeda	NA	
Virginia		29,532
Alexandria	21,568	
Peninsula Compost Site (James River, York River, and Nansemond)	3,982	
Upper Occoquan	2,489	
Moores Creek	1,493	
Washington		3,318
Seattle (West Point)	3,318	
Wisconsin		796
Portage	796	
Milwaukee (Jones Island)	NA	
National Total		384,848-390,452[a]

[a] Total derived from Biocycle Survey does not correspond to sludge totals assigned to distribution and marketing using the Needs Survey since POTWs were assumed in this analysis to practice only one form of sludge disposal. In fact, many POTWs compost only a portion of their sludge, which is reflected in the lower amounts reported in Biocycle.

Source: ERG research; Sludge Composting Facilities on the Rise, 1987 Biocycle Survey, Nov/Dec 1987, Biocycle.

The list was compiled from information provided in the 1987 Biocycle survey of composting facilities and a list of facilities provided by a compost facility design consultant. Also, two POTWs heat-dry sludge for distribution and marketing. They use a flash drying process that removes up to 92 percent of the moisture in the sludge. A total of 106 POTWs currently practice distribution and marketing.

EPA conducted research to determine the ultimate end uses of composted or heat-dried sludge. First, 24 POTWs known to have composting operations were contacted and queried as to the end uses of their sludge product. In addition, EPA obtained raw data from the 1986 and 1987 Biocycle surveys of composting operations, and compiled data from the 52 POTWs that responded to Biocycle's questions regarding end uses. The results of these two research efforts are presented in Table 3-14. A weighted average of the two survey results was calculated and is shown in the table.

Our analysis shows that the most common end users of composted sludge are landscapers and plant nurseries (40 percent). The next most common users are municipalities (27 percent) for parks, highways, etc.

The results of the two surveys were roughly parallel except for the categories landscaping/nurseries and brokers/contractors. The Biocycle survey results showed a much higher percentage (49 percent as compared with 22 percent) going to landscaping/nurseries. Conversely, the Biocycle results had a lower figure for brokers/contractors (5 percent as compared with 22 percent). One might justifiably speculate that much of the compost sold by brokers is intended for use by landscaping companies and plant nurseries, thus bringing the two survey results approximately in line with each other.

3.4.4 Land Application and Landfilling

As already stated, there will be no new requirements for codisposal of sewage sludge under the new sludge disposal regulations. Only monofills (sludge-only landfills) will be subject to additional costs. Therefore, a

TABLE 3-14

THE DISTRIBUTION OF END USES AMONG POTWs USING DISTRIBUTION AND MARKETING

	PERCENT OF RESPONSES[a]		
END USE	ERG SURVEY RESULTS[c]	*BIOCYCLE* SURVEY DATA RESULTS[d]	WEIGHTED AVERAGE[e]
General Population	17	11	13
Public Works Departments	24	28	27
Reclamation	2	0	0.5
Landscaping/Nurseries	22	49	40
Landfill Cover/Closure	10	2	4.5
Compost Brokers/Contractors	22	5	10
Farmers	2	6	5
Total[b]	100	100	100

[a] Some POTWs gave more than one response (i.e., more than one end use applied).

[b] Totals may not add due to rounding.

[c] Based on a survey of 24 POTWs.

[d] Based on a survey of 52 POTWs.

[e] An average of the two survey results was calculated weighted by the number of POTWs surveyed in each case.

Source: The ERG survey results were compiled from telephone contacts to 24 POTWs known to have composting operations. The *Biocycle* survey data results were derived from data in completed survey questionnaires provided by *Biocycle* from their 1986 and 1987 annual survey of composting operations.

separate list of POTWs known to have sludge monofills was assembled. EPA regional personnel and state sludge program staff were contacted to identify POTWs using sludge monofills. Additional contacts were made to verify and obtain key information on the use of monofills. Table 3-15 lists the POTWs identified as using monofills. Forty-nine POTWs are known to use monofills either on the POTW site or at another location.

A list of land application and codisposal facilities was developed through a computerized manipulation of the 1986 Needs Survey Database. The first step in this analysis was to "eliminate" from consideration any facilities already identified as employing ocean dumping, incineration, monofilling, or D&M. The lists of facilities using these options (Tables 3-8, 3-12, 3-13, and 3-15) were matched to the Needs Survey Database to ensure that none of the facilities on these four lists would be considered to employ land application or codisposal.

After the first step had been completed, the remaining facilities (i.e., those with potential for using codisposal or land application) were reviewed in accordance with the following assumptions:

- If land application alone or land application with incineration, D&M, monofilling, or ocean disposal was specified by the POTW in the Needs Survey, land application was assumed as the disposal option. Since all the POTWs using these other options were already established, land application could be the only possible option.
- For POTWs that specified both land application and landfilling in the Needs Survey, land application was assumed as the disposal option for 80 percent and landfill for 20 percent. This assumption was made based on a verification of 100 POTWs listed as using both landfills and land application in the Needs Survey; the verification concluded that about 20 percent of the POTWs that reported both options used landfills for sludge disposal.
- If just landfilling was indicated by the POTW in the Needs Survey, landfilling was assumed to be the disposal option used.
- All other POTWs were assigned to the "Other" disposal method category. Most of these plants use lagoons. Some plants may send their wastewater or sludge to another plant for further treatment or disposal and, therefore, do not indicate any disposal method on the Needs Survey. Boston and Los Angeles treatment plants were also put in this category because they are changing their sludge disposal method from ocean discharge.

TABLE 3-15

POTWs USING SLUDGE MONOFILLS

FACILITY	COMMENTS
Arizona	
Payson	Monofill off POTW site
Illinois	
Waukegan	The three Illinois POTWs use the same monofill
Gurnee	
NSDD-Clavey Rd STP	
Indiana	
Bloomington	Monofill on POTW site
Maine	
August	Monofill off site
Lewiston-Auburn	Monofill off site
Berwick	Monofill on site
Hartland	Monofill off site
South Paris	Monofill off site
Springvale (Sanford WWTP)	Monofill on site
Massachusetts	
Marlborough	Monofill on site
Brockton	Monofill on site
Wareham	Monofill on site
Haverhill	Monofill off site
Pittsfield	Monofill on site
Northbridge	Monofill on site
Easthampton	Monofill on site
Hudson	Monofill on site
North Attleboro	Monofill off site
Milford	Monofill on site
Taunton	Monofill on site
Northfield	Monofill on site
Millers Falls	Monofill off site shared with Erving
Erving	Monofill off site shared with Millers Falls
Lee	Monofill on site
North Brookfield	Monofill on site
Ayer	Monofill on site
North Lenox	Monofill on site
Stockbridge	Monofill on site
Uxbridge	Monofill on site
Hopedale	Monofill on site

TABLE 3-15 (continued)

FACILITY	COMMENTS
Douglas	Monofill on site
Medway (Charles River WWTF)	Monofill on site
Upton	Monofill on site
Baldwinsville Templeton WWTF	Monofill on site
Missouri	
North Kansas City	Monofill on site
New Hampshire	
Milford	Monofill on site
Somersworth	Monofill on site
Franklin	Monofill on site
Rhode Island	
Bristol	Monofill off site
Burrillville	Monofill on site
East Greenwich	Monofill off site
Block Island (New Shoreham)	Monofill off site
Westerly	Monofill off site
Blackstone Valley (Bucklin Point STP)	Monofill on site
Texas	
Grand Prairie	Monofill on site
Utah	
Midvale (South Valley WRF)	Monofill off site
Ogden (Central Weber WWTP)	Monofill off site

Source: ERG and Abt research.

1518S

Table 3-16 shows the distribution of sludge disposal methods that resulted from this analysis. Of all POTWs, a total of 2,623 use land application methods other than distribution and marketing; 6,664 use codisposal.

The proposed regulation provides different criteria for different methods or end uses of land application (i.e., agriculture or nonagricultural end uses). The criteria proposed for sludge applied to food chain crops are different from those proposed for sludge spread over nonagricultural lands. Our data indicate that 17 percent of all POTWs use land application options for sludge disposal. No data are available, however, indicating the distribution of end uses among these POTWs. Verifications from 125 POTWs that use land application provided information with respect to the ultimate end use of the sludge. Table 3-17 summarizes these results. POTWs that reported more than one end use were counted in more than one category. Approximately half of the responses indicated feed crop farm land as the ultimate end use. Pasture land was the second most common end use.

3.4.4.1 Current Constraints on Landfill Capacity and Siting New Landfills

Constrained landfill capacity is fairly widespread in the United States. In addition, siting new landfills is becoming increasingly difficult due to environmental considerations and public opposition. Since many POTWs currently use codisposal landfills for sewage sludges (see Section 3.4.5), these issues will affect future trends in sludge disposal practices. This section briefly examines the current status of solid waste landfills in the United States.

Several states are looking for alternatives to landfill disposal, such as refuse-to-energy or recycling, for their existing load of municipal waste.[8] Soon-to-be-proposed Subtitle D regulations may make the current capacity shortage noted in many states even more severe since constructing new landfills will most likely become more difficult and costly than at present. Additionally, under the proposed Subtitle D regulations, certain stringent siting and retrofit requirements may be involved for landfills in high net

TABLE 3-16

THE NUMBER OF POTWs USING EACH SLUDGE DISPOSAL METHOD, BY SIZE

DISPOSAL OPTION	SIZE OF POTW (MGD)					
	0≤0.2	0.2≤1	1≤10	10≤60	>60	TOTAL
Distribution and Marketing	5	27	45	16	13	106
(% of total)	(.03)	(.18)	(.29)	(.10)	(.08)	(.69)
Land Application	1,071	889	591	65	7	2,623
(% of total)	(7.0)	(5.81)	(3.86)	(.42)	(.05)	(17.14)
Landfilling	2,718	2,359	1,420	151	16	6,664
(% of total)	(17.76)	(15.41)	(9.28)	(.99)	(.10)	(43.54)
Ocean Dumping[a]	0	2	3	6	14	25
(% of total)	(0)	(.01)	(.02)	(.04)	(.09)	(.16)
Incineration	0	3	71	76	19	169
(% of total)	(0)	(.02)	(.46)	(.50)	(.12)	(1.10)
Monofilling	5	14	19	10	1	49
(% of total)	(.03)	(.09)	(.12)	(.07)	(.01)	(.32)
Other	4,658	847	139	23	2	5,669
(% of total)	(30.43)	(5.53)	(.91)	(.15)	(.01)	(37.04)
Surface Impoundments	1,968	358	59	9	1	2,395
(% of total)	(12.86)	(2.34)	(0.39)	(0.06)	(0.01)	(15.65)
Other	2,690	489	80	14	1	3,274
(% of total)	(17.58)	(3.20)	(0.52)	(0.09)	(0.01)	(21.39)
Total	8,457	4,141	2,288	347	72	15,305
(% of total)	(55.26)	(27.06)	(14.95)	(2.27)	(.47)	(100.0)

[a] Two new POTWs using ocean disposal were not on the Needs Survey data base and, therefore, are not included in the totals shown.

[b] Based on analysis that indicates approximately 42 percent of POTWs using other disposal methods use surface impoundments for disposal.

Source: ERG Database of POTWs (See text).

1517S

TABLE 3-17

THE DISTRIBUTION OF END USES AMONG POTWs USING LAND APPLICATION

END USE	NUMBER OF RESPONSES	PERCENT OF TOTAL
Farm Land (feed crops)	81	51
Farm Land (Crops for direct human consumption)	8	5
Sod Farms	4	2
Pasture Land	22	14
Nurseries (Nonfood-chain plants)	5	3
Dedicated Land	10	6
Home Gardens	3	2
Reclamation	5	3
Soil Conditioning (General)	16	10
Golf Courses	2	1
Parks, City Property, and Cemeteries	4	3
Total	160	100

Source: ERG research.

1519S

precipitation areas. Virtually all the eastern half of the country is in a high net precipitation zone. This is also the area of the country with some of the most severe capacity limitations.

Several recent studies address the issue of landfill capacity. A survey of landfill operators[9] determined that all currently active landfill capacity in Florida, Massachusetts, New Jersey, and New Hampshire would be filled within the next 10 years. The study also concluded that within 15 years, nearly three-quarters of all existing municipal landfills expect to close. Additionally, it was noted that in the 1970s, about 300 to 400 new landfills were constructed each year. In 1985 and 1986, however, only about 60 were constructed annually.

Another survey,[10] conducted by Newsday (a New York daily newspaper), concluded that half of existing landfills will run out of room in the next 10 years. Newsday reported that 14 out of 40 (35 percent) states and territories with solid waste management plans intend to phase out landfills as a municipal waste disposal option. These states plan to emphasize recycling, garbage-to-energy solutions, composting, reductions in waste generation, and other alternatives. Only 16 states (40%) included construction of more landfills as one of their waste management objectives.

A third study (a "phase one" effort to characterize the existing data on municipal landfills for a soon-to-be-released Report to Congress[11]) provides qualitative data based on a survey of state personnel familiar with landfill capacity and siting issues.[12] This study reveals that 65 percent of all states and territories have capacity problems or siting problems or both.

The following sections summarize the data from all three studies by EPA Region (Figure 3-1 presented a map of the EPA regions).

Region I

All Region I states report widespread capacity shortages. In particular, capacity shortages in Connecticut were described as "critical." Siting problems compound the shortages; this state has not permitted a landfill since 1978. Connecticut is phasing out landfills as a waste disposal option, as is New Hampshire, which is opting for refuse-to-energy solutions in several towns. New Hampshire is predicted to fill all existing landfill capacity within 10 years, and has closed over 30 landfills in the past 5 years, as has Maine. Massachusetts is predicted to fill all existing landfill capacity in the next 10 years.

Region II

New Jersey and Puerto Rico report "severe" and "enormous" capacity problems, with concomitant siting problems. New Jersey noted that its siting problems were the largest contributing factor to its capacity problems. The state, which will most likely have filled all current capacity in the next 10 years, plans to phase out landfills as a disposal option. In New York, an estimated 218 out of 294 landfills are expected to close between March 1986 and January 1996. By January 2006, only 13 landfills are expected to be functioning. These figures reflect closings due to capacity only and do not reflect closings due to environmental reasons.

Region III

All states in this region except Delaware report severe capacity problems, and Delaware plans to phase out landfills as a municipal waste disposal option. Many areas of the reporting states (including southeast Pennsylvania, one-third of all jurisdictions in Maryland, in all areas of West Virginia and near urban areas in Virginia) will reach capacity within the next 3 to 6 years. Public resistance to siting landfills is noted for Pennsylvania and Virginia.

Region IV

Alabama, Florida, and South Carolina noted some capacity problems. Georgia reports limited capacity in the Atlanta area, which is also an area where landfills are particularly difficult to site. Georgia has also closed more than 30 landfills in the last 5 years, as has Florida. Florida is also expected to deplete its current landfill capacity within the next 10 years, and both Florida and Kentucky are planning to phase out landfills as a municipal waste disposal option. In Tennessee, urban area sites are difficult to permit, and public opposition to landfill siting is an acute problem in middle Tennessee. Tennessee has also closed more than 30 landfills in the past 5 years, as has Mississippi and Alabama. Only North Carolina appears to have no immediate landfill capacity problems.

Region V

Michigan notes no problems with capacity and siting, while Wisconsin has only short-term, localized problems and is siting landfills at about 10 to 20 per year. Michigan, however, is phasing out landfills as a waste disposal objective for municipal waste. Capacity problems are more apparent in Ohio, in which nearly half of current landfills have less than 5 years remaining capacity and in which more than 30 landfills have closed in the last 5 years. Illinois, Indiana, and Minnesota have also closed more than 30 landfills in the last 5 years. Minnesota is actively stressing reuse of waste and hopes to need less capacity in the future. Both Minnesota and Illinois intend to phase out landfills as a waste disposal option.

Region VI

New Mexico and Oklahoma both report extensive capacity problems as well as siting difficulties. Texas does not specify any current capacity problems, although it has closed over 30 landfills in the past 5 years. Siting in urban areas is a difficulty in Texas, and the state plans to phase out landfill disposal as an option for municipal waste. Louisiana lacks capacity for oil and gas wastes, but does not describe specific siting problems or capacity problems for municipal wastes. Only Arkansas, which notes that a few facilities have reached capacity and which has closed 30 landfills in the past 5 years, states that there is no problem siting landfills.

Region VII

Few problems with either capacity or siting are apparent in this region. Only Nebraska notes some capacity problems. Kansas, however, plans to phase out landfills as municipal waste disposal options.

Region VIII

North Dakota and South Dakota have no capacity or siting problems; however, North Dakota plans to phase out landfill disposal for municipal waste. Wyoming notes capacity problems in a few areas (notably the Yellowstone area) and predicts it will have siting problems state-wide within the next 10 years. Many of Montana's landfills are nearing capacity, and siting is difficult. More than 30 landfills have been closed in the past 5 years in Montana and Colorado. Colorado has "critical" capacity problems near Denver, with no replacement landfills proposed.

Region IX

California has only about 20 years of capacity left in most urban areas and has no current siting plans. Both California and Arizona, which has had difficulty siting landfills, have closed more than 30 landfills each in the past 5 years. Nevada has no problems, but Hawaii has both capacity and siting problems.

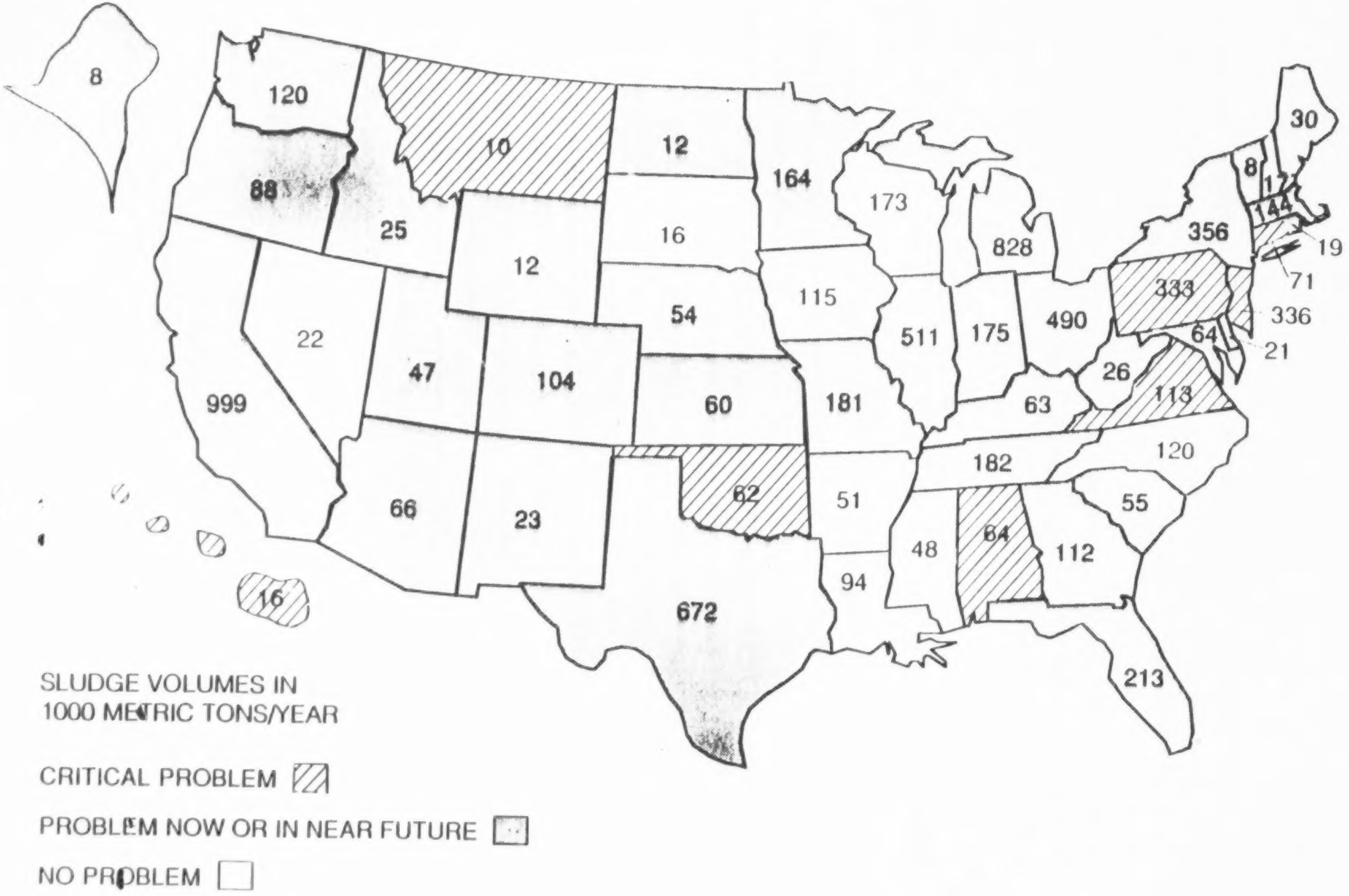
Region X

All states in this region except Washington and Alaska note moderate to severe capacity problems. Washington, however, predicts siting problems in the future, especially near urban sites. This state has also closed more than 30 landfills in the past 5 years. Alaska lacks suitable sites due to its climate. Oregon's capacity problems are limited to the Portland area where half the state population resides, but plans to phase out landfills as a municipal waste disposal option.

Summary

Figure 3-3 summarizes the information above using a map of the United States for illustration. The base map reports data on sludge generation in each state in thousands of metric tons per year. The overlay represents judgements made on the status of landfill capacity and siting issues in each state. Three categories were used to describe the status: (1) critical problem; (2) problem now or in the near future; and (3) no problem. States were judged to have a critical problem if they noted both siting problems and capacity problems or had stressed that their problems were "severe" or "critical." States that noted only capacity or siting problems now or in the future and those planning to phase out landfills as a waste disposal option were placed in the second category. States that noted their problems were transient or those which stated they had no problems were put in the third category. States that had closed numerous landfills, but had not noted any problems, were still classified as having no problems; those for which no capacity or siting information was available, but which had closed numerous landfills, were assumed to have a problem now or in the future.

In general, states east of the Mississippi have little to no remaining landfill capacity, and resistance to siting has made the addition of landfill capacity difficult. Nine states out of 30 states/territories in Regions I, II, III, IV, and V (30 percent) are planning to phase out landfills as a disposal options. Nineteen states (63 percent) have either capacity problems


8
120
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999
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181
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26
113
120
182
66
23
62
51
55
64
48
112
94
16
672
213
SLUDGE VOLUMES IN
1000 METRIC TONS/YEAR
CRITICAL PROBLEM ▨
PROBLEM NOW OR IN NEAR FUTURE ▩
NO PROBLEM ☐

Figure 3-3. Landfill capacity and sludge generation by state.

or siting problems or both. Of the states remaining, only three (10 percent) appear to have no problems (information on the Virgin Islands and Washington D.C. was not available).

In the West, landfill capacity problems appear somewhat less severe. Even so, 17 states/territories out of 25 (68 percent) in Regions VI, VII, VIII, IX, and X have some problem with capacity or siting. In many of these states, however, these problems are only apparent near urban areas. Five states (20 percent) plan to phase out landfills in the these regions. Only five states (20 percent) are noted to have no problems.

In many cases, critical problem areas are also associated with high levels of sludge generation. In all cases, the states that generate over 500 MT per day are states that have a critical problem, or a problem now or in the near future. Several of the states with no problem are also associated with small quantities of sludge generation. This general relationship between sludge generation and landfill capacity problems may limit the ability of many POTWs to codispose sludge.

Additionally, many states that generate smaller quantities of sludge and/or that did not appear to have widespread capacity or siting problems noted critical problems with capacity and/or siting near urban areas. Since POTWs also tend to be sited near urban areas, this could further limit the codisposal option for many POTWs.

3.4.5 Distribution of Sludge Volume by Disposal Method

The volume of sludge generated by POTWs using the various sludge disposal options was estimated based on the volume of wastewater processed as reported in the Needs database and the following methodology. For each POTW, the annual volume of sludge was calculated based on the difference between the total influent suspended solids and the total effluent suspended solids of the wastewater. (Data from 239 POTWs had to be excluded from the database because of inaccurately reported or missing data on influent and effluent suspended solids.) The total amount of sludge generated was estimated to be 7.7 million dry metric tons per year. The total yearly tonnage of sludge for POTWs using each disposal option was tabulated and is shown in Table 3-18. The largest volume of sludge is attributed to POTWs using codisposal, and the smallest volume is attributed to plants using monofills. The other category attributable to surface impoundments was calculated to be 42 percent of the total estimate volume of sludge presented here. This estimate is discussed in more detail in Section 4.3.6.

This estimation method has two major drawbacks. First, sludge volume is overestimated for some POTWs because the reductions in sludge volume for plants using digestors is unaccounted for. Second, sludge volume is underestimated for some POTWs because lime or other chemical additions and BOD conversion during sludge processing is not taken into account. Notwithstanding these caveats, using the difference between influent and effluent solids is a common way to approximate sludge generated by POTWs when data are limited.

3.5 Sludge Characteristics

The wastewater treatment processes described in Section 3.1 remove solid and dissolved contaminants from the influent wastewater. The contaminants found in the sludges, therefore, depend on the contaminants discharged into the sewer system and on the removal processes used at the treatment plant. Organic and inorganic compounds from domestic, commercial, and industrial wastewater become concentrated in sludge. This section describes the constituents of wastewater sludge and presents a profile of the contaminants of concern to public health and the environment.

TABLE 3-18

ESTIMATES OF SLUDGE GENERATION BY SLUDGE DISPOSAL OPTION[a]

(Dry Metric Tons Per Year)

DISPOSAL OPTION	SIZE CLASS OF POTW (MGD)					
	0 TO 0.2	0.2 TO 1	1 TO 10	10 TO 60	>60	TOTAL
DISTRIBUTION & MARKETING	138	4,040	36,317	97,455	567,535	705,485
(% of Total)	<0.01	0.05	0.47	1.26	7.36	9.14
INCINERATION	0	634	94,143	383,557	1,173,083	1,651,416
(% of Total)	0	0.01	1.22	4.97	15.21	21.41
LAND APPLICATION	23,127	103,048	438,318	321,512	316,153	1,202,158
(% of Total)	0.3	1.34	5.68	4.17	4.10	15.58
CODISPOSAL	56,468	278,552	1,043,137	899,496	884,692	3,162,345
(% of Total)	0.73	3.61	13.52	11.66	11.47	40.99
MONOFILLING	148	2,759	25,468	44,495	28,506	101,375
(% of Total)	<0.01	0.04	0.33	0.58	0.37	1.31
OCEAN DISPOSAL	0	262	1,233	35,444	387,437	424,377
(% of Total)	0	<.01	0.02	0.46	5.02	5.5
OTHER[b]	65,455	79,335	96,874	189,242	36,604	467,510
(% of Total)	0.85	1.03	1.26	2.45	0.47	6.06
Surface Impoundments	27,653	33,517	40,927	79,950	15,464	197,510
(% of Total)	0.36	0.43	0.53	1.03	0.20	2.56
Other	37,802	45,818	55,947	109,292	21,140	270,000
(% of Total)	0.49	0.59	0.73	1.42	0.27	3.50
TOTAL	145,335	468,630	1,735,489	1,971,201	3,394,011	7,714,666
(% of Total)	1.88	6.07	22.5	25.55	43.99	100

[a] Sludge estimates from 239 POTWs are not included in the total because the data from the Needs Survey needed to calculate sludge volume was missing or insufficient.

[b] Approximately 42 percent of sludge volume is estimated to be associated with surface impoundments in each size class.

Source: ERG Database of POTWs (See text).

Note: Totals may not add due to rounding.

1330S

3.5.1 Overview of the Major Constituents in Wastewater Sludge

There are five classes of constituents in sludge: organic matter, pathogens, nutrients, metals, and toxic organic chemicals. The mix and levels of certain constituents will ultimately determine the public health and environmental impact of disposal, and may also dictate the most appropriate disposal method.

Organic Matter

Organic matter in sludge is primarily composed of proteins, carbohydrates, fats, grease, and oils. These substances are derived from human waste, kitchen waste, and storm water runoff. The organic content of sludge can be measured in a number of ways. One method is to measure the volatile solids as a fraction of the total solids (TS). A more widespread method expresses organic content in terms of the biochemical oxygen demand (BOD). This method quantifies the oxygen needed to metabolize or degrade the volatile portion of the solids biologically or chemically.

The organic content of sludge is reduced during anaerobic and aerobic digestion, composting, and other stabilization techniques. Table 3-19 compares the typical organic content of sludge, expressed as volatile solids, as a percentage of total solids in untreated primary sludge and digested sludge. The grease and fat content as well as the protein content are also presented. After digestion, volatile solids are significantly reduced from a typical value of 65 percent of total solids to 40 percent. The organic content of the sludge governs the thermal value, the soil conditioning potential, and the potential for gas generation as a result of digestion. As shown in the table, the thermal content of sludge is reduced following digestion from 16.5 to 9 megajoules per kilogram.

TABLE 3-19

TYPICAL COMPOSITION OF UNTREATED AND DIGESTED SLUDGE

	UNTREATED PRIMARY SLUDGE		DIGESTED SLUDGE	
COMPONENT	RANGE	TYPICAL	RANGE	TYPICAL
Volatile solids (% of TS)	60-80	65	30-60	40.0
Grease and fats (ether-soluble, % of TS)	6.0-30.0	--	5.0-20.0	--
Protein (% of TS)	20-30	25	15-20	18.0
Thermal content (MJ/kg)	14-23	16.5[a]	6-14	9[b]
Nutrients				
Nitrogen (N, % of TS)	1.5-6.0	4.0	1.6-6.0	4.0
Phosphorus (P_2O_5, % of TS)	0.8-3.0	2.0	1.5-4.0	2.5
Potash (K_2O, % of TS)	0-1.0	0.4	0.0-3.0	1.0

[a] Based on 65 percent volatile matter.

[b] Based on 40 percent volatile matter.

Source: Wastewater Engineering, Treatment/Disposal/Reuse, Second Edition, Metcalf and Eddy, Inc., McGraw Hill Publishers, 1978.

Note: MJ/kg x 429.92 = Btu/lb.
TS = Total Solids

1343S

Nutrients

Municipal sludges contain nitrogen, phosphorus, and potassium, all of which are plant nutrients present in commercial fertilizers. The concentrations of nutrients in municipal sludges are typically lower than those in commercial fertilizers. Fertilizers typically contain 5 percent nitrogen, 10 percent phosphorus, and 10 percent potassium by dry weight. As shown in Table 3-19, sludges typically contain 4 percent nitrogen, 2 to 2.5 percent phosphorus, and 0.4 to 1 percent potash (potassium oxide).

Pathogens

A significant portion of the bacteria, viruses, other protista, and parasitic eggs contained in wastewater tend to concentrate in sludge. Some of these organisms may be pathogenic. Depending on the disposal method used, pathogen levels may have to be reduced to limit human exposure to disease-carrying organisms.

The presence of pathogens is generally measured by determining the presence and concentration of indicator organisms. Typically, total fecal coliform bacteria counts are used to gauge the presence of dangerous organisms. Other measures for pathogens include virus counts and *Salmonella* and *Ascaris lumbricoides* bacterial counts.

A typical count of fecal coliform bacteria for unstabilized sludge is one billion per hundred milliliters of sludge. Anaerobic digestion significantly reduces fecal coliform bacteria to levels typically ranging from 30,000 to 60,000 per hundred milliliters of sludge.[13]

Current federal regulations (40 CFR 257) require that sludge be treated by a "Process to Significantly Reduce Pathogens" (PSRP) or a "Process to Further Reduce Pathogens" (PFRP) before being applied to land. These processes refer to the use of stabilization techniques, such as composting, digestion, or liming, to diminish pathogen concentrations in sludge. Compliance with these standards is measured by the overall reduction in total fecal coliform. Federal regulatory requirements are discussed more fully in Section 3.7.

Metals

Sludges contain varying concentrations of heavy metals and inorganic ions, depending largely on the volume and type of industrial wastes discharged to the POTW system. In trace concentrations, some metals are beneficial to plants, animals, and humans. Metals can be toxic when they occur in higher concentrations.

Metals are one of the sludge constituents of most concern when choosing a safe disposal method. Land application and distribution and marketing have the greatest potential for exposing plants, animals and, ultimately humans, to metals. Through these disposal practices, metals enter the food chain. If soil conditions are acidic, metals can become soluble and may leach into groundwater from sludge-amended soil or a sludge landfill, thus becoming a potential source of drinking water contamination. Also, under certain operating conditions, metals can be released to the atmosphere through incinerator emissions.

Organic Chemicals

Sludges can contain toxic organic chemicals that are synthesized during industrial processes and discharged to municipal sewers. Some organics enter the sewers from the effluent of manufacturing facilities. Pesticides may enter the sewage system through nonpoint sources or industrial discharge. Households also contribute organic compounds derived from cleansers and other household chemicals. As is the case with metals concentrations, high levels of toxic organics and pesticides can be a major concern if land application, distribution and marketing, or landfilling are used for the disposal of sludge.

3.5.2 Typical Levels of Selected Contaminants in Sludge

The previous section described the typical constituents of wastewater sludge. Only some of these constituents will be specifically controlled in the proposed sludge disposal regulations.

Of all the contaminants considered by EPA, 30 will be restricted under the proposed regulations (see Table 3-20). These 30 were selected as a result of an extensive study effort by EPA.[14] This effort began with a list of the priority pollutants and some other contaminants deemed to be of potential concern. EPA established the environmental pathways of each pollutant, assigned hazard index values to each pollutant in each pathway, and ranked the pollutants according to their estimated degree of risk. Those pollutants ranking below the point that indicated no potential risk, based on the available data under the assumed worst case scenario, were eliminated from the analysis. Further analysis and sensitivity studies were conducted by EPA to determine the final set of contaminants regulated under each disposal option.

One of the only comprehensive sources of data regarding the typical levels of pollutants in wastewater sludge is an EPA study completed in 1981, Fate of Priority Toxic Pollutants in Publicly Owned Treatment Works (often referred to as the "Forty-City Study"). While the Forty-City Study was not specifically designed to provide supporting data for the proposed sludge disposal regulations, it did provide data from the largest sample of nationally distributed treatment plants. EPA used data from the Forty-City Study to profile representative sludge contaminant levels.

Three sludge profiles were developed to represent sludges from wastewater treatment plants. One sludge profile represents plants with a typical industrial load, the second represents plants with a high industrial load, and the third represents plants with a very high industrial load. The median concentrations of each pollutant reported by the Forty-City Study were used to represent typical sludges. The 90th percentile concentrations were used to represent the high industrial load sludges and the 98th percentile

TABLE 3-20

POLLUTANTS CURRENTLY COVERED BY THE PROPOSED SLUDGE DISPOSAL REGULATIONS

	POLLUTANTS TO BE REGULATED FOR EACH DISPOSAL METHOD				
POLLUTANT	D&M	LAND APPLI- CATION	MONO- LAND- FILL	INCIN- ERATION	SURFACE DISPOSAL
Metals					
Copper	X	X		X	X
Cadmium	X	X	X	X	X
Zinc	X	X			
Lead	X	X	X	X	X
Nickel	X	X		X	X
Chromium	X	X		X	
Selenium	X	X			
Molybdenum		X			
Mercury	X	X	X	X	X
Arsenic	X	X	X	X	X
Beryllium				X	
Organics					
Benzene					X
Trichloroethylene		X	X		X
Bis(2-ethylhexyl) phthalate			X		X
Hexachlorobenzene	X	X			
Hexachlorobutadiene	X	X			
Benzo(a)pyrene	X	X	X		X
Dimethyl Nitrosamine		X	X		X
Chlordane	X	X			X
PCBs	X	X	X		X
Dieldrin	X	X			
DDT	X	X	X		X
DDE	X	X	X		X
Lindane	X	X	X		X
Aldrin	X	X			
DDD	X	X	X		X
Heptachlor	X	X			
Toxaphene	X	X	X		X
Total Hydrocarbons				X	

Source: Proposed regulations and Summary of Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methods and Results, EPA, July 1985.

concentrations were used to represent sludges with the highest industrial load. Table 3-21 lists the concentrations of contaminants for all three categories.

The percent industrial contribution of each POTW, as reported in the Needs Survey, was used to assign the typical, 90th percentile, and 98th percentile designations to each POTW. Before this assignment was finalized, corrections had to be made to the percent industrial contribution data due to inconsistently reported values in the Needs Survey. Then, the typical sludge profile was assigned to those POTWs having an industrial contribution of approximately 17 percent or less (90 percent of the POTWs). POTWs with higher industrial contributions, i.e., greater than 17 percent but less than 55 percent (which accounts for approximately 8 percent of the POTWs) were assigned to the 90th percentile category. Finally, those POTWs with an industrial contribution greater than 55 percent (2 percent of all POTWs) were assigned to the 98th percentile category.

3.5.3 Potential Implications of the National Pretreatment Program on Future Contaminant Levels in Sludge

Pretreatment can play an important role in reducing the concentrations of metals, inorganic chemicals, and organic chemicals in wastewater sludges. Two factors will determine the impact of pretreatment on the ability of POTWs to comply with the maximum pollutant levels in sludge specified in the proposed regulations: (1) the degree of overlap between the pollutants controlled by pretreatment programs and those restricted by the proposed regulations; and (2) the improvement in sludge quality achievable through stricter pretreatment actions.

Pollutants Covered by the Categorical Pretreatment Standards

The categorical pretreatment standards control priority pollutants that are commonly discharged by certain industries. Table 3-22 summarizes the pollutants that have numerical limits for each industry category. Table 3-20 lists the pollutants to be regulated under the proposed regulations.

TABLE 3-21

TYPICAL CONTAMINANT CONCENTRATIONS
(mg/kg)

CONTAMINANT	TYPICAL SLUDGES	90TH PERCENTILE SLUDGES	98TH PERCENTILE SLUDGES
Metals			
Arsenic	4.359	16.39	36.4
Beryllium	0.843	3.94	10.0
Cadmium	11.189	101.72	384.6
Chromium	248.164	1190.64	3063.0
Copper	411.000	1507.94	3300.3
Lead	265.741	821.87	1622.8
Mercury	1.735	7.21	17.0
Molybdenum	13.217	78.40	229.2
Nickel	70.114	365.39	998.0
Selenium	1.446	9.06	27.4
Zinc	979.834	3806.37	8622.4
Base Neutrals			
Benzidene	0.281	0.780	1.445
Benzo(a)pyrene	0.001	0.234	6.911
Bis(2-ethylhexyl)phthalate	104.796	367.158	781.527
Dimethyl Nitrosamine	0.281	0.780	1.445
Hexachlorobenzene	0.040	0.568	2.753
Hexachlorobutadiene	0.112	0.312	0.578
Volatiles			
Benzene	0.336487	3.6598	15.42
Trichloroethylene	0.529272	20.1945	181.22
Pesticides and PCBs			
Aldrin	0.0048651	0.2094687	0.0872404
Chlordane	0.0048651	0.0294684	0.0872404
DDD	0.0048651	0.0294687	0.0872404
DDE	0.0067135	0.0331443	0.0867462
DDT	0.0048651	0.0294687	0.0872404
Dieldrin	0.0048651	0.0294687	0.0872404
Heptachlor	0.0048651	0.0294687	0.0872404
Lindane	0.0048651	0.0294687	0.0872404
PCB	0.0048651	0.0294687	0.0872404
Toxaphene	0.0048651	0.0294687	0.0872404

Source: EPA Office of Water, April, 1987.

Note: If measurement was reported as being less than a number Y, the value Y was used in the analysis. If measurement was reported as not detected, zero was used in the analysis.

TABLE 3-22

CONTAMINANTS CONTROLLED UNDER CATEGORICAL STANDARDS, BY CATEGORICAL INDUSTRY

CATEGORICAL INDUSTRY	CONTROLLED POLLUTANT
Aluminum Forming	Chromium, Cyanide, Zinc, TTO
Battery Manufacturing	Chromium, Cyanide, Zinc, Copper, Lead, Cadmium, Nickel, Cobalt, Silver, Mercury, Manganese, Fluoride, Phosphorus
Coil Coating	Chromium, Cyanide, Zinc, TTO, Copper, Manganese, Fluoride, Phosphorus
Copper Forming	Chromium, Zinc, TTO, Copper, Lead, Nickel, Oil and Grease
Electroplating	Chromium, Cyanide, Zinc, TTO, Copper, Lead, Cadmium, Nickel, Silver, Total Metals, TSS, pH
Electrical and Electronic Components	Chromium, Zinc, TTO, Lead, Cadmium, Fluoride, Arsenic, Antimony
Inorganic Chemicals	Chromium, Zinc, Copper, Lead, Cadmium, Nickel, Cobalt, Silver, Mercury, Fluoride, TSS, pH, Arsenic, Antimony, Iron, Selenium, COD
Iron and Steel	Chromium, Cyanide, Zinc, Tetrachloroethylene, Lead, Nickel

TABLE 3-22 (continued)

CATEGORICAL INDUSTRY	CONTROLLED POLLUTANT
Leather Tanning and Finishing	Sulfide, Chromium, pH
Metal Finishing	Chromium, Cyanide, Zinc, TTO, Copper, Lead, Cadmium, Nickel, Silver
Non-Ferrous Metals Manufacturing	Cyanide, Zinc, Copper, Benzo(a)pyrene, Lead, Cadmium, Nickel, Fluoride, Arsenic, Antimony, Ammonia
Petroleum Refining	Chromium, Oil and Grease, Ammonia
Pharmaceutical Manufacturing	Cyanide
Porcelain Enameling	Chromium, Zinc, Lead, Nickel
Pulp, Paper, and Paperboard[a]	Zinc, Pentachlorophenol, Trichlorophenol
Timber Products Processing	Chromium, Copper, Oil and Grease, Arsenic
Steam Electric Power Generating	No numerical limitations
Textile Mills	No numerical limitations

[a] And builder's paper and board mills.

Source: National Categorical Pretreatment Standards.

Note: TTO = Total Toxic Organics

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Comparing the two lists indicates the degree to which both sets of requirements control the same pollutants. Nine of the 11 metals being considered for regulation under the new criteria are controlled under certain categorical standards. Of the nonmetals, benzo(a)pyrene is also on both lists.

The categorical standards cover additional organic chemicals through the Total Toxic Organic (TTO) limitations. The TTO measurement indicates the total level of toxic organic chemicals present in sludge. For industrial users subject to TTO limitations, the pretreatment program requires that samples of wastewater be analyzed for certain organic compounds and that the total level of these toxics be determined. The specific organic compounds to be analyzed vary by industry. As shown in Table 3-23, the TTO list overlaps an additional 17 contaminants covered by the proposed sludge disposal regulations. Thus, most of the pollutants considered for coverage under the sludge disposal regulations are controlled by the categorical pretreatment standards. Additional pollutants may be regulated by individual POTWs through the implementation of locally established limits on toxic pollutants (i.e., local limits).

Effect of Pretreatment on Sludge Quality

Before the National Pretreatment Program was implemented, EPA developed estimates of the degree to which sludge quality was likely to improve as the result of industrial pretreatment. These results are reported in Table 3-24. The left-hand column shows contaminant reductions from detailed case studies of previous pretreatment programs; the right-hand column shows projections of sludge contaminant reductions likely to be achieved with full implementation of the National Pretreatment Program. Both data sets show reductions of contaminant levels in sludge of more than 40 percent for total metals.

The National Pretreatment Program requires sewage treatment plants to implement more stringent controls than the categorical standards if it is necessary to prevent passthrough and interference or otherwise implement the

TABLE 3-23

COMPOUNDS THAT MUST BE TESTED UNDER BOTH THE TOTAL TOXIC ORGANICS MONITORING REQUIREMENT AND THE PROPOSED SLUDGE DISPOSAL REGULATIONS

POLLUTANTS COVERED BY THE PROPOSED SLUDGE REGULATIONS	TTO PRETREATMENT STANDARDS BY INDUSTRY					
		ELECTRICAL AND ELECTRONIC COMPONENTS				
	ELECTROPLATING AND METAL FINISHING	SEMICONDUCTORS AND ELECTRONIC CRYSTALS	CATHODE RAY TUBES	COPPER FORMING	ALUMINUM FORMING	COIL COATING
Organics						
Benzene	X	-	-	X	-	-
Trichloroethylene	X	X	X	X	X	-
Bis(2-ethylhexyl)phthalate	X	X	X	-	X	X
Hexachlorobenzene	X	-	-	-	-	-
Hexachlorobutadiene	X	-	-	-	-	-
Benzo(a)pyrene	X	-	-	-	X	-
Benzidine	X	-	-	-	-	-
Dimethyl Nitrosamine	-	-	-	-	-	-
Chlordane	X	-	-	-	-	-
PCBs	X	-	-	-	X	-
Dieldrin	X	-	-	-	-	-
DDT	X	-	-	-	-	-
DDE	X	-	-	-	-	-
Lindane	-	-	-	-	-	-
Aldrin	X	-	-	-	-	-
DDD	X	-	-	-	-	-
Heptachlor	X	-	-	-	-	-
Toxaphene	X	-	-	-	-	-

Source: Comparison of data in Table 3-20 and in: U.S. EPA, 1985, Guidance Manual for Implementing Total Toxic Organics Pretreatment Standards, Office of Water.

TABLE 3-24

REDUCTION IN CONTAMINANT LEVELS IN SLUDGE DUE TO PRETREATMENT

(Percentage Reduction in Pollutant Levels)

POLLUTANT PARAMETER	REDUCTIONS REPORTED IN CASE STUDIES OF LOCAL PRETREATMENT PROGRAMS	REDUCTIONS PROJECTED WITH FULL IMPLEMENTATION OF THE NATIONAL PRETREATMENT PROGRAM
Silver	N/A	2
Cadmium	20	14
Chromium	74	64
Copper	51	42
Mercury	-	50
Nickel	75	61
Lead	71	15
Zinc	51	34
Cyanide	N/A	N/A
Total Metals	49	43
Total Organics	N/A	75
Benzene	N/A	28
Toluene	N/A	28
Phenol	N/A	32
1,1,1-Trichlorethane	N/A	96
Bis(2 EH) Phthalate	N/A	0

Source: JRB Associates, addendum to the report entitled Assessment of the Impacts of Industrial Discharges on Publicly Owned Treatment Works, February 1983.

prohibited discharge standards. Local limits can be established for all dischargers. For some industrial processes, pretreatment technologies can attain higher removal efficiencies than the technologies used to establish the categorical standards. EPA examined the potential improvement in sludge quality from these additional pretreatment controls. Eight case studies were performed to estimate the magnitude of the reductions that can be achieved by dischargers subject to categorical standards if the most stringent pretreatment technologies were used. These case studies are presented in Section Five.

The case studies show that industrial pretreatment can have a significant effect on the pollutant concentrations in a POTW's sludge. Categorical pretreatment standards and locally imposed pretreatment requirements can play an important role in a POTW's ability to control its sludge quality and, in turn, to comply with the proposed regulation.

One of the limitations of this RIA is the database of sludge quality used to derive the typical, 90th percentile, and 98th percentile sludge profiles. The Forty-City Study collected information before many categorical pretreatment standards were implemented. Thus, the pollutant concentrations used to determine compliance may not reflect the effect of existing pretreatment. The Agency is pursuing this area of data collection and future analysis. For the purposes of this RIA, however, the Forty-City Study is used as the basis for the assumptions concerning sludge contaminant levels.

3.6 Economic Profile of POTWs

Municipal authorities that operate the wastewater collection systems and the wastewater treatment plants bear the costs of wastewater treatment and sludge disposal. These agencies obtain construction funds through grants and municipal bonds and operating funds through sewer use charges. If new regulations increase costs, the funds necessary to cover the additional sludge disposal expenses will come from these same, predominantly local, sources.

This section examines the economic structure of POTWs, their revenues and costs, and the significance of sludge disposal expenses in the context of overall POTW operations.

Although POTWs are a national industry, responsible for a vital community service and billions of dollars of revenues and expenditures, aggregate economic statistics concerning the industry are not maintained within the Standard Industrial Classifications (SICs) of the Department of Commerce or any other regularly maintained time-series database. The economic information presented below, therefore, relies on a variety of other data sources, including EPA cost surveys, engineering design manuals, sludge disposal case studies, and annual reports of individual sewer authorities.

3.6.1 Overview of POTWs

The term "publicly owned treatment works" refers to the system of sewers, pumping stations, and treatment plants that convey and treat a community's wastewater. The organizations that own and operate POTWs differ from community to community. Some POTWs are located within a given political jurisdiction, such as a city. In this case, the city government or a specially designated sewage authority chartered by the city operates the sewers and the treatment plant.

Where the POTW serves more than one municipality, interjurisdictional agreements are required to ensure the coordinated functioning of the system. In some cases, one municipality may operate the treatment facilities while the other jurisdictions operate only their own sewers. The municipality operating the treatment plants may bill the other jurisdictions for sewage treatment services based on the contribution of each jurisdiction to the overall flow.

In other situations, several POTWs may share the processing of sewage sludge at a large, centralized facility. POTWs often share disposal methods as well. For example, several POTWs combine their sludge for ocean disposal; some POTWs share sludge landfills.

Several municipalities using a sewer system and treatment plant may also delegate operating responsibilities to a separate level of government. The level of government operating the sewers and treatment plant may be part of county government or an entirely separate sewage authority set up to provide wastewater conveyance and treatment services. The sewage authority may bill each town for wastewater removal and treatment services. The towns, in turn, may bill individual users, or the authorities may bill all users directly.

In addition to the sewage authority and the municipalities, a number of other organizations may be involved in the operation of a sewage system and treatment plant. Contractors may provide sewer maintenance, plant operation, sludge removal, billing, and fee collection. State and federal governments may appropriate funds for facilities and enforce water pollution control regulations. Thus, control of all aspects of sewage treatment, including obtaining operating revenues, paying expenses, operating facilities, and complying with regulations, is highly individualized among POTWs.

Despite the diversity of the organizational structure of POTWs, they all share certain common economic features:

- Capital Costs. POTWs incur capital costs to construct, expand, and improve the sewage collection system and the sewage treatment plant.
- Operating and Maintenance (O&M) Costs. POTWs incur substantial costs to operate and maintain the collection system and treatment plant 24 hours per day.
- Sludge Disposal Costs. As part of its O&M activities, POTWs must safely treat and remove the sludge that is generated continually at the sewage treatment plant.
- Revenue Requirements. POTWs must raise revenues to pay for the cost of sewer and treatment plant operations, sludge disposal, and interest and principal payments required to finance capital purchases.

3.6.2 Capital Costs

New construction, major repairs, and additions to existing systems require the outlay of capital. Capital projects are undertaken in response to expanding needs of growing communities, the need to replace obsolete equipment or systems, or the development of new housing communities or new industrial/commercial facilities that require a separate collection system and treatment works.

Treatment Plant

The cost of constructing a treatment plant and a conveyance system today is several times the cost of construction 40 years ago. Yet, many treatment plants built 40 years ago are still in operation. These facilities may be fully depreciated on the accounting records of the POTW. The value of capital-in-place for the typical treatment plants is estimated below. The capital costs presented reflect the expenses necessary to construct a facility in 1987. Thus, these costs represent the replacement costs (rather than book value) of an existing facility.

Two approaches to estimating the costs of treatment plants are presented in Tables 3-25 and 3-26. First, in the Needs Survey, states reported their dollar needs for the construction of new treatment plants. These data were used to calculate the average cost of facilities in each size class (Table 3-25). Note that the capital costs of treatment plants vary from $323,000 to more than $276 million.

A second set of estimates of capital costs for treatment facilities employs a series of construction cost equations developed by EPA (Table 3-26).[15] These equations were derived based on statistical analyses of actual construction projects. The capital costs presented in Table 3-26 ranged from $305,000 to nearly $170 million. Costs vary directly with facility size and level of treatment.

TABLE 3-25

AVERAGE TOTAL COST OF CONSTRUCTING TREATMENT PLANTS
(1987 $ 000)[a]

SIZE CATEGORY (Design Flow, in MGD)	TYPE OF TREATMENT		
	SECONDARY	ADVANCED SECONDARY	ADVANCED
0-0.10	$ 323	$ 499	$ 882
0.11-0.50	1,044	1,428	1,614
0.51-1.05	2,832	2,942	3,312
1.06-5.01	7,016	6,394	7,942
5.02-10.56	15,234	15,407	10,033
10.57-50.19	48,735	31,573	31,554
> 50.2	276,213	209,296	NA

[a] Dollar figures were first updated to 1985 dollars based on the EPA Construction Cost Indices published by the Office of Water Program Operations, Facilities Requirements Division, First Quarter calendar year 1985. They were later updated to 1987 dollars based on the GNP Fixed Weight Price Index for government purchases of goods and services (U.S. Department of Commerce). The EPA Construction Cost Indices are not available for 1987.

Source: The 1982 Needs Survey Summaries of Technical Data, EPA, May 1983. (Data to calculate the equivalent figures were not available from the 1986 Needs Survey.)

NA = Not available (no plants of this size in this category).

1524S

TABLE 3-26

ESTIMATED TOTAL CAPITAL-IN-PLACE FOR REPRESENTATIVE TREATMENT PLANTS (1987 $000)

SIZE CATEGORY (Design Flow, in MGD)	AVERAGE FACILITY SIZE (MGD)	LEVEL OF TREATMENT				
		PRIMARY[a]	SECONDARY	ADVANCED SECONDARY	ADVANCED	NO DISCHARGE[b]
0-0.105	0.05	$ 305	$ 402	$ 376	$ 473	$ 373
0.106-1.05	0.4	1,343	1,767	1,791	2,124	1,284
1.06-10.5	3.3	6,432	8,463	9,348	10,399	4,756
10.57-50.2	21.6	25,783	33,926	40,431	42,485	15,174
>50.2	140.0	100,440	132,157	169,678	168,608	47,270

[a] The total cost of a primary treatment plant was estimated by reducing the cost of the secondary plant by the percentage of the cost attributed to the activated sludge unit process. The actual percentage for plants from the small to largest size class was 22 to 26 percent. The midpoint of this range, or 24 percent, was used.

[b] All plants in this category are assumed to be aerated lagoon or stabilization pond systems with land treatment.

Source: Capital costs were calculated using equations developed by EPA for estimating new treatment plant construction costs. These equations were published in: Construction Costs for Municipal Wastewater Treatment Plants: 1973-1978, EPA, April 1980 (EPA/430/9-80-003). Costs were inflated to 1987 dollars using the GNP Fixed Weight Price Index for government purchases of goods and services (U.S. Department of Commerce).

1525S

3.6.3 Operating and Maintenance Costs

Operating and maintenance costs (O&M) are the day-to-day expenses of running the treatment plant and the conveyance system. O&M expenses include all the costs of operating the system with the exception of major capital equipment items. These expenses fall into several categories: personnel, utilities, chemicals, equipment, materials, contractors, and a variety of "miscellaneous" costs. The O&M costs presented here include sludge disposal costs, but these costs are not broken out as a separate category; rather they make up a part of the costs in each category. (Sludge disposal costs are described in more detail in Section 3.6.4.)

Personnel costs, the largest component of O&M expenses, include the wages and fringe benefits of regular full- or part-time employees. Additional personnel may be supplied by outside contractors for specialized services, such as sludge disposal, billing, repairs, and a variety of other O&M functions. Some POTWs have agreements with contractors to haul and dispose of sludge based on a fee per ton removed. Contractor expenses are generally itemized separately from personnel expenses.

Utility costs, comprising electricity and other fuel sources used at the plant, are another major cost item. Energy is required to pump, dry, and aerate wastewater and sludge. Some facilities recapture energy from sludge through cogeneration or through the combustion of methane gas produced during sludge digestion.

Chemical costs vary from plant to plant depending on the level of treatment and the characteristics of the wastewater. Typical chemical additives include lime, alum, ferric chloride, polymers to aid flocculation, and other mineral salts. Large quantities of chlorine are used generally to disinfect the effluent before it is discharged from the treatment plant.

Equipment and material costs cover a wide range of expenses. These costs can include tools, replacement parts, and other equipment items that must be replaced frequently.

Table 3-27 shows typical O&M costs of facilities in various size classifications employing varying levels of treatment. These costs were generated using general cost equations developed by EPA based on data from 900 treatment plants. Annual O&M costs for the treatment plant vary from $13,000 to more than $6.9 million for the representative facilities.

Table 3-28 shows typical costs for each category of O&M expenditures for two facility sizes. Personnel costs account for the largest percentage of O&M costs by far, followed by utilities. These two categories account for approximately 70 percent of facility O&M costs.

In addition to O&M costs for the treatment plant and sewers, POTWs incur administrative costs for oversight, billing, and accounting of all facilities. These costs, presented in Table 3-29, account for 5 to 10 percent of all POTW O&M expenditures.

3.6.4 Sludge Disposal Costs

Sludge processing and disposal costs are a major expense for most POTWs. Sludge disposal costs comprise two major components: transportation costs and disposal site costs. A number of factors may affect one or both of these components:

- Water Content. Facilities producing sludges with a high water content will have a larger mass of sludge to dispose of per pound of solids removed. This will lead to higher transportation costs and higher disposal costs.
- Contaminant Content. If the level of contaminants is too high, the sludge may be defined as hazardous waste. Even if sludge is not considered hazardous, high levels of metals or organic contaminants may restrict some disposal options.
- Availability of and Distance to Disposal Sites. Treatment plants located in metropolitan areas may not have access to land for landfill or land application at a reasonable cost. The necessity to transport sludge over longer distances greatly increases disposal costs.

TABLE 3-27

TYPICAL TREATMENT PLANT ANNUAL OPERATION AND MAINTENANCE COSTS

(1987 $000)

SIZE CATEGORY (MGD)	AVERAGE FACILITY SIZE (MGD)	LEVEL OF TREATMENT		
		SECONDARY	ADVANCED SECONDARY	ADVANCED
0 - 0.105	0.05	$ 13	$ 10	$ 17
0.106 - 1.05	0.4	63	57	79
1.06 - 10.5	3.3	330	328	401
10.57 - 50.2	21.6	1,429	1,553	1,691
Greater than 50.2	140.0	5,998	7,096	6,939

Source: Total operation and maintenance costs were calculated using the equations developed by EPA in Operation and Maintenance Costs for Municipal Wastewater Facilities, Office of Water Program Operations, EPA, September 1981 (430/9-81-004). Costs were first updated to 1985 dollars using the Average O&M Escalation Index for wastewater treatment plants published by EPA. Costs were later updated to 1987 dollars using the GNP Fixed Weight Price Index for government purchases of goods and services (U.S. Department of Commerce).

1526S

TABLE 3-28

TYPICAL O&M COSTS BY COST COMPONENT FOR TWO SIZES OF TREATMENT PLANTS

(1987 $000)

COST COMPONENT	LEVEL OF TREATMENT SECONDARY COST (% OF TOTAL)	 ADVANCED SECONDARY COST (% OF TOTAL)	 ADVANCED COST (% OF TOTAL)
0.05 MGD Plant			
Personnel	5.88 (44.9)	5.23 (48)	7.02 (42.9)
Utilities	3.19 (24.3)	2.83 (26)	4.68 (28.6)
Chemicals	0.85 (6.5)	0.77 (7)	1.10 (6.7)
Equipment & Materials	1.72 (13.1)	0.77 (7)	2.02 (12.4)
Contractual & Other	1.47 (11.2)	1.20 (11)	1.55 (9.5)
Total O&M	13.11 (100)	10.91 (100)	16.36 (100)
140.0 MGD Plant			
Personnel	2,693.18 (44.9)	3,406.31 (48)	2,976.89 (42.9)
Utilities	1,457.55 (24.3)	1,845.09 (26)	1,984.59 (28.6)
Chemicals	389.88 (6.5)	496.75 (7)	464.93 (6.7)
Equipment & Materials	785.76 (13.1)	496.75 (7)	860.45 (12.4)
Contractural & Other	671.80 (11.2)	780.61 (11)	659.22 (9.5)
Total O&M	5,998 (100)	7,096 (100)	6,939 (100)

Source: Cost components of total O&M were calculated using percentages derived by EPA in Operation and Maintenance Costs for Municipal Wastewater Facilities, Office of Water Program Operations, EPA, September 1981 (430/9-81-004). Costs were first updated to 1985 dollars using the Average O&M Escalation Index for wastewater treatment plants published by EPA. Costs were later updated to 1987 dollars using the GNP Fixed Weight Price Index for government purchases of goods and services (U.S. Department of Commerce).

Note: Totals may not add due to rounding.

1527S

TABLE 3-29

TYPICAL TREATMENT PLANT ANNUAL ADMINISTRATIVE COSTS

SIZE CATEGORY (MGD)	AVERAGE FACILITY SIZE (MGD)	ANNUAL ADMINISTRATIVE COSTS (1987, $ 000)
0-0.105	0.05	$ 2.0
0.106-1.05	0.4	7.6
1.06-10.5	3.3	30.5
10.57-50.2	21.6	106.0
Greater than 50.2	140.0	358.0

Source: Total administrative costs were calculated using the equations developed by EPA in Operation and Maintenance Costs for Municipal Wastewater Facilities, Office of Water Program Operations, EPA, September 1981 (430/9-81-004). Costs were first updated to 1985 dollars using the Average O&M Escalation Index for Wastewater Treatment Plants published by EPA. Costs were later updated to 1987 dollars using the GNP Fixed Weight Price Index for government purchases of goods and services (U.S. Department of Commerce).

Note: Administrative costs for secondary, advanced secondary, and tertiary treatment facilities were found to be virtually the same by EPA. Thus, only one set of administrative costs is presented.

1528S

- Disposal Method. The cost of available disposal methods (land application, landfill, distribution and marketing, incineration, and ocean disposal) may differ significantly as described below.

Sludge disposal cost information was reviewed from a number of sources. The most extensive body of information on sludge disposal costs was developed by SCS Engineers and published in Handbook for Estimating Sludge Disposal Costs at Municipal Wastewater Treatment Facilities.[16] This document provides a series of equations for estimating sludge disposal costs based on the characteristics of a treatment plant and its sludge. The annual costs of various sludge disposal methods for five sizes of facilities (0.1, 0.5, 2, 14, and 128 MGD) are shown in Table 3-30. Incineration is the most costly option for all model plant sizes. Table 3-31 presents the baseline sludge disposal costs for each model plant and each disposal method on a per-ton-of-sludge-disposed basis. For a given disposal method, disposal costs per ton decrease significantly as facility size increases.

The costs in Tables 3-30 and 3-31 are used to represent baseline sludge disposal costs. Incremental costs of compliance with the proposed standard will be compared to these baseline costs in later sections of the report. Sludge disposal costs in both tables include annualized capital costs, annual operation and maintenance costs, and transportation costs to the disposal site. The model plant sizes were chosen to provide representative costs for the regulated POTWs in the U.S.

The costs of codisposal of sewage sludge were also examined. Although codisposal of sewage sludge will not be regulated under the proposed standards, it is useful to establish baseline costs of codisposal for reference as a disposal alternative to the regulated practices.

The cost of codisposal is not easy to pinpoint since neither the estimated costs of operating landfills nor the fees charged by these facilities are completely adequate for estimating the true cost of disposal. The majority of landfills are government-owned (either federal, state, county or local); only 15% are commercial facilities. Many of the government-owned facilities (particularly municipal operations) may not know their exact costs for

TABLE 3-30

SLUDGE DISPOSAL COSTS FOR REPRESENTATIVE FACILITIES
($ 1987)

MODEL PLANT SIZE (MGD)	DISPOSAL OPTION						
	INCINERATION	DISTRIBUTION AND MARKETING	MONOFILL	DEDICATED LAND APPLICATION	CROP APPLICATION	RECLAMATION	SURFACE IMPOUND-MENTS
0.1	a	$ 17,885	$ 6,625	$ 6,134	$ 5,226	$ 14,003	$ 5,226
0.5	$ 268,882	$ 50,857	$ 20,269	$ 21,796	$ 19,835	$ 39,528	$ 19,835
2	$ 343,653	$ 144,889	$ 108,946	$ 91,222	$ 78,098	$ 138,910	$ 78,098
14	$ 883,132	$ 506,406	$ 259,044	$ 176,466	$ 142,960	$ 538,943	$ 142,960
128	$4,368,400	$4,180,362	$1,569,767	$1,201,207	$1,204,948	$4,589,681	$1,204,948

[a] There are no POTWs using incineration in this size class.

[b] Assumed similar to costs for crop application - to be updated.

Source: Crossmedia Impact Analysis model assumptions, EPA, Temple, Barker & Sloane, and Handbook for Estimating Sludge Management Costs, Water Engineering Research Laboratory, EPA, October, 1985.

Note: Sludge disposal costs include annualized capital and annual O&M costs for disposal processes, and transportation to the disposal site (if applicable).

1530S

TABLE 3-31

ANNUAL DISPOSAL COSTS PER DRY METRIC TON OF SLUDGE
($1987)

MODEL PLANT SIZE (MGD)	ANNUAL SLUDGE GENERATION PER FACILITY (DRY METRIC TONS/YR)	DISPOSAL OPTION						
		INCINERATION	DISTRIBUTION AND MARKETING	MONOFILL	DEDICATED LAND APPLICATION	CROP APPLICATION	RECLAMATION	SURFACE IMPOUND-MENTS[b]
0.1	22	a	$813	$301	$279	$238	$636	$238
0.5	111	$2,422	$458	$183	$196	$179	$356	$179
2	445	$ 772	$326	$245	$205	$176	$312	$176
14	3,116	$ 283	$163	$ 83	$ 57	$ 46	$173	$ 46
128	28,478	$ 153	$147	$ 55	$ 42	$ 42	$161	$ 42

[a] There are no POTWs using incineration in this size class.

[b] Assumed similar to crop application - to be updated.

Source: Crossmedia Impact Analysis model assumptions, EPA, Temple, Barker & Sloane, and Handbook for Estimating Sludge Management Costs, Water Engineering Research Laboratory, EPA, October, 1985.

Note: Sludge disposal costs include annualized capital and annual O&M costs for disposal processes, and transportation to the disposal site (if applicable).

operating the landfill.[17] Operating costs may be better known, but capital costs may be hidden within the complexities of municipal funding mechanisms. Additionally, the tipping fees charged by these municipal landfills often do not reflect the true cost of disposal, since many municipal or regional landfills charge reduced fees or no fee to the municipalities they serve.

EPA conducted a survey of landfill operators to gather data on typical operating costs.[18] Operating costs varied widely, depending on the size of the facility. The median operating cost was determined to be $11/wet metric ton. The reported cost data may or may not include capital expenditures. The study concluded that these reported costs are less than the total costs.

Using some of the data collected by the survey and a landfill cost model developed by Pope-Reid Associates, EPA modeled the costs of constructing and operating facilities of various sizes. EPA estimated the weighted average total cost of constructing and operating solid waste landfills at $35/wet metric ton.

The National Solid Wastes Management Association (NSWMA) also conducted a survey, which looked strictly at tipping fees, or the fees charged by landfill operators for disposal. Again, these fees may not necessarily reflect the true cost of disposal since certain users may be subsidized from other sources. They are, however, a good representation of the costs that a POTW seeking a disposal facility would face. The survey is not an unbiased random sample, but it is a geographically diverse sample of 36 states and Washington, D.C. Based on this survey, (among those landfills charging a fee) the national average tipping fee was estimated to be about $20/wet metric ton.

Regionally, the tipping fees vary considerably, sometimes reflecting the capacity and siting constraints. In the Northeast, the average cost/ton was estimated to be nearly $40/wet metric ton. In the South and Midwest, costs averaged about $12 to 13/ton. In the West, where landfill capacity appears to be less of a problem than in other regions, costs were the lowest at about $11/ton or about 55% of the national total. Overall costs in the survey ranged from about $3/wet metric ton (Boise, ID) to about $75/wet metric ton (Fall River, MA).

The percent increase in disposal costs between 1986 and 1987 also supports the contention that landfill disposal is becoming more difficult, particularly in the Northeast. The West showed the smallest increase of 7 percent. Disposal costs in the South and Midwest increased 12 percent and 17 percent, respectively, between 1986 and 1987. Not surprisingly, the biggest increase was found in the Northeast, where disposal costs increased by 90 percent. The NSWMA survey also noted that the trend toward higher prices should continue, due to tightening landfill rules, dwindling capacity, and the increased use of refuse-to-energy plants, which have generally higher tipping fees because of stricter environmental regulation and lower energy sales revenues. The survey also points to strong trends towards recycling and other efforts to reduce waste volumes going to landfills.

Thus, the cost of codisposing sewage sludge in landfills can be chosen as either the price seen by the POTW (the tipping fee), estimated to be on average $20/wet metric ton, or the modeled cost of landfill disposal, estimated to be $35/wet metric ton. For purposes of this RIA, the modeled costs were chosen to represent baseline costs since capital and operating costs are known to be included. These costs are more consistent with the modeled costs of regulated disposal options presented in Tables 3-30 and 3-31.

The potential costs of implementing new Subtitle D landfill requirements, which are to be proposed in the very near future (see Section 3.7.1), are not reflected in these costs. EPA used its model to calculate the impact of these requirements on the baseline costs of disposal. Using two scenarios, one in which more stringent federal requirements would be met and one in which less stringent state requirements would be met (which states might optionally choose), EPA estimated that these new regulations would add approximately $11/wet metric ton or $10/wet metric ton to the current costs of landfill disposal, respectively. Thus, total costs under the Subtitle D revisions, assuming the more stringent federal regulations would have to be met, would be $46/wet metric ton, which is $209/dry metric ton.

For use in the RIA, another cost component must be added. In addition to the disposal cost, transportation costs will be incurred. Based on the models used to derive other sludge disposal costs in the RIA, transportation costs to and from a codisposal landfill were estimated. These costs ranged from $17 to $131/dry metric ton depending on the size of the model plant (the highest cost is associated with the smallest plant). Thus, the total disposal and transportation costs for codisposal range from $226 to 340/dry metric ton based on the Subtitle D regulated scenario. Since promulgation of the Subtitle D revisions is expected before promulgation of the proposed sludge disposal regulations, it is appropriate to use the estimated regulated costs of codisposal for the baseline.

3.6.5 Revenue Requirements

POTW capital and operating expenses described above are covered by a variety of sources, such as sewer use charges, general local tax revenues, and bond issues. Table 3-32 provides an indication of the annual revenues necessary to maintain operations at a POTW with secondary treatment capability. The table summarizes the information compiled in Sections 3.6.2 through 3.6.3. POTWs use different sources of revenue for capital expenses than those used to meet O&M expenses.

Capital Expenses

As described in Section 3.6.2, the construction of a treatment facility may require large capital outlays. Clean Water Act provisions requiring secondary treatment of municipal wastewaters have necessitated major renovations of existing plants and/or the construction of new facilities. Capital costs for wastewater treatment facilities may be partially financed through EPA construction grants with the balance raised through sales of general obligation or revenue bonds.

TABLE 3-32

TOTAL ANNUAL O&M AND CAPITAL COSTS FOR A TYPICAL SECONDARY TREATMENT FACILITY
(1987, $000)

		CAPITAL COSTS					
SIZE CATEGORY (MGD)	AVERAGE FACILITY SIZE (MGD)	TREATMENT PLANT	ANNUALIZED PORTION[a]	ANNUAL CAPITAL[b]	ANNUAL O&M	ANNUAL ADMINISTRATIVE COSTS	TOTAL ANNUAL COSTS
0 - 0.105	0.05	$ 402	$ 101	$ 10	$ 13	$ 2.0	$ 25
0.106 - 1.05	0.4	1,767	442	47	63	7.6	117
1.06 - 10.5	3.3	8,463	2,116	229	330	30.5	590
10.57 - 50.2	21.6	33,926	8,481	916	1,429	106.0	2,450
Greater than 50.2	140.0	132,157	33,039	3,569	5,998	358.0	9,925

[a] Twenty-five percent of capital costs were assumed to be annualized costs borne by the POTW. This is based on the premise that most POTWs receive 75 percent of total construction costs through the Construction Grants Program, state grants, or other outside sources and that some capital equipment items are fully depreciated.

[b] Capital costs were annualized assuming an 8.8 percent cost of capital and a 20-year plant and equipment life.

Source: ERG analysis. Figures for secondary treatment plant capital and O&M costs from Tables 3-26, 3-27, and 3-29 and are used.

The EPA Construction Grants Program was established under the Clean Water Act (CWA) to provide capital funds necessary for compliance with CWA provisions. The Construction Grants Program provides funding for several types of projects. The federal share for most projects under the Construction Grants Program is 55 percent for projects commencing October 1, 1984. The federal share can increase to 75 percent for innovative/alternative technologies.

EPA is, however, phasing out the grant program and will fully implement a loan program by FY 1991. Under this program, states will be given money to set up a revolving fund from which loans can be given to municipalities for treatment plant projects.

Operating Costs

Funds for sewer and treatment plant operations are derived primarily through user charges. User charges are assessed in one of several ways:

- Volume. Most residential water users are assessed a sewage service charge based on the volume of water consumed.
- Pollutant Loading. Some sewage districts base user charges on the loading of some pollutants, such as BOD or suspended solids. This type of charge is typically applied to industrial users.
- Type of Connections. In some sewer districts, users are charged a flat rate based on the number and type of sewer and water connections (e.g., number of faucets, sinks, toilets, etc.).

Using the revenue requirements of wastewater treatment facilities shown in Table 3-32, the annual per capita sewer charges necessary to recover the costs of these representative facilities may be calculated. The results of these calculations are shown in Table 3-33. Sewer use charges range from $16 to $108 per person. Assuming 3 persons per household, charges range from $47 to $324 per household. These costs may be overstated because: (1) some costs are paid via general tax revenues; and (2) industrial users may pay a substantial proportion of system costs. (It should be noted that these

TABLE 3-33

TREATMENT FACILITY ANNUAL COSTS PER HOUSEHOLD
($1987)

SIZE CATEGORY (MGD)	FACILITY SIZE (MGD)	POPULATION SERVED	TOTAL ANNUAL COST ($000)	ANNUAL COST PER HOUSEHOLD ($/HOUSEHOLD)
0 - 0.105	0.05	234	$ 25	$324
0.106 - 1.05	0.4	1,732	$ 117	$205
1.06 - 10.5	3.3	14,906	$ 590	$120
10.57 - 50.2	21.6	99,855	$2,450	$ 72
Greater than 50.2	140.0	643,300	$9,925	$47

Source: ERG estimates.

1532S

charges cover the treatment plant costs only. The costs of the conveyance system (i.e., the sewers rather than the treatment plant) would be added to these charges for the total sewer use fee.)

3.7 Existing Regulations Regarding the Disposal and Use of Municipal Wastewater Sludge

A number of current regulations govern the disposal and use of municipal wastewater sludge. Federal regulations governing the disposal of sludge are set forth under several legislative mandates. State regulations vary in terms of stringency and consistency among states. Table 3-34 summarizes the extent of the existing federal and state regulations pertaining to sludge disposal. This section provides a summary of the contents of these regulations. The discussion is organized according to sludge disposal option, with federal and state mandates addressed in each section.

3.7.1 Incineration

The incineration of nonhazardous municipal wastewater sludge is regulated under the Clean Air Act (CAA). TSCA regulates the incineration of wastes containing PCBs; Subtitle C of RCRA regulates the incineration of sludges containing hazardous wastes other than PCBs.

Two types of regulations under the CAA affect the incineration of nonhazardous sludge: (1) ambient air-quality standards; and (2) point-source numerical emissions limits. The National Ambient Air Quality Standards (NAAQS) govern the overall ambient air quality in the United States. States must develop and enforce State Implementation Plans (SIPs) designed to meet and maintain NAAQS. NAAQS have been promulgated for 6 pollutants: ozone, particulates, sulfur oxides, nitrogen dioxides, carbon monoxide, and lead. The areas that do not meet NAAQS are designated as "nonattainment areas." Areas that meet the standards are "in attainment." In nonattainment areas, states must have measures in their SIPs to bring ambient air quality into compliance with the NAAQS.

TABLE 3-34

A SUMMARY OF SLUDGE MANAGEMENT REGULATIONS

DISPOSAL METHOD	FEDERAL REGULATIONS	STATE REGULATIONS
Landfill	40 CFR 257 40 CFR 761 40 CFR 261-268	32 states have regulations; 14 have guidelines set on case-by-case basis.
Land Application	40 CFR 257	33 states have regulations or guidelines.
Incineration	40 CFR 761 40 CFR 61 40 CFR 60 40 CFR 50	Controlled by State Implementation Plans. 30 states have regulations; 4 set guidelines on a case-by-case basis.
Distribution and Marketing	None	6 states have regulations; 15 set guidelines lines on a case-by-case basis.
Ocean Disposal	40 CFR 220-228	Some states apply state ban on ocean disposal in addition to federal ban.

Source: Environmental Regulations and Technology: Use and Disposal of Municipal Wastewater Sludge, EPA, Technology Transfer, EPA 625/10-84-003, September 1984; A Review of State Programs to Control the Disposal and Utilization of Municipal Sewage Sludge: Implications for the Federal Regulatory Program, EPA Sludge Task Force, March 1983.

1533S

The ambient standards influence the choice of sludge disposal methods. If a POTW in a nonattainment area wishes to switch to incineration, the CAA requires that a reduction in emissions from existing sources be at least equal to the expected incremental emissions from the new source. A POTW could not construct an incinerator unless the tradeoff conditions are met. In attainment areas, an incinerator could be added only if the additional emissions would not affect attainment status.

In addition to the NAAQS program, sludge incinerators are covered by two federal programs that establish numerical limits on incinerator emissions: the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) and New Source Performance Standards (NSPS). The NESHAPs give EPA the authority to promulgate point-source emission standards for specific pollutants. To date, EPA has promulgated standards pertaining to sewage sludge incinerators for mercury and beryllium (40 CFR 61). For sludge incinerators, mercury emissions are limited to less than 3,200 grams and beryllium to 10 grams per 24-hour period. NESHAPs also stipulate stack and sludge sampling and monitoring practices.

The NSPS regulations apply to those incinerators that have been constructed or significantly altered since June 11, 1973, and those that burn more than 10 percent wastewater sludge (on a dry basis) or more than 1,000 kg of wastewater sludge per day. These standards restrict the discharge of particulates to 0.65 g/kg of dry sludge input (40 CFR 60). The NSPS also prohibits discharge of gases that exhibit 20 percent opacity or greater.

On April 18, 1986, EPA proposed revisions to the NSPS requirements for sewage treatment plants. The proposal included additional monitoring, recordkeeping, reporting, and performance test requirements for owners and operators of existing and future sewage sludge incinerators. These proposed revisions were to become final in the latter half of 1987. The effects of the proposed NSPS revisions on the assumptions of baseline incineration practices for this analysis are discussed in Section Four.

Two other major regulatory programs apply to the incineration of wastewater sludge. Subtitle C of RCRA covers the incineration of hazardous sludge. Incinerators that burn hazardous sludges are designated as Treatment Storage Disposal Facilities (TSDFs) and must obtain a special permit. Also under RCRA, federal agencies operating incinerators that process 50 tons or more per day of "municipal-type solid wastes" are subject to the thermal processing guidelines set forth in 40 CFR 240. These guidelines specify minimum levels of operating performance. Recommended operating procedures and designs are included in the code as well. The residue of thermal processing (ash) must be disposed of in an environmentally acceptable manner. These thermal processing guidelines are recommendations to state and local government agencies as well.

The Toxic Substances Control Act (TSCA) regulates incineration of sludge that has 60 parts per million or more of PCBs (40 CFR 761). If sludge PCB concentrations exceed this level, TSCA requires that EPA approve the incinerator before operation. The operator must also abide by technical and procedural requirements specified in the law, such as monitoring and recordkeeping.

As to state controls on incineration of sewage sludge, overall emissions rates are covered under the State Implementation Plans. Sixty percent of states have regulations on emissions from incinerators. Many of these state regulations apply to all incinerators and do not set unique requirements for municipal wastewater sludge. Very few states set operational requirements, such as processing temperatures, air turbulence, or residence time specifications. Almost half of the states that do control incineration restrict the disposal of the ash. One state does not allow incineration of sewage sludge and 14 other states have no sludge incinerators within their boundaries.

3.7.2 Ocean Disposal

Ocean disposal has recently been banned. All such activity must cease by 1992.

3.7.3 Land Disposal of Sludge

Federal Regulations

Federal regulations pertaining to land disposal of sludge have been promulgated under Subtitles C and D of the Resource Conservation and Recovery Act (RCRA). Subtitle C requirements apply if the sludge is considered a hazardous waste. If the sludge is not considered hazardous, disposal of the sludge through landfilling, land application, and lagooning is regulated under Subtitle D of RCRA.

Subtitle C Requirements

Subtitle C of RCRA governs the generation, storage, transport, and disposal of hazardous waste. Wastewater sludges are subject to the Extraction Procedure (EP) toxicity test to determine whether they should be designated as hazardous waste. (40 CFR 261 Appendix II defines the criteria for determining whether a waste is hazardous.) This test defines maximum concentrations for eight metals and six organic compounds, and also specifies toxicity testing procedures. The owner or operator of the POTW is responsible for determining whether the sludge or incinerator ash is hazardous. If wastewater sludges are designated as hazardous, the POTW must participate in the permit program for treatment and storage of hazardous waste and dispose of the sludge at a permitted Subtitle C facility. Most municipal wastewater sludges, however, are not hazardous.

A new test, the Toxicity Characteristic Leaching Procedure (TCLP) test, has been proposed to replace the EP Toxicity test. This proposal is expected to be adopted in 1988, at which time the TCLP test will be the required test for determining whether a waste is hazardous. For purposes of this report, it is assumed that sewage sludges currently considered nonhazardous will continue to be classified as such under the new test procedures.

Subtitle D Requirements

Land-disposed sludges that do not fall under the hazardous waste classification must meet requirements set forth in Subtitle D of RCRA. Land application sites, landfills, and lagoons are all subject to the rules in 40 CFR 257. These rules specify management practices for land disposal that protect floodplains, surface water, and ground water:

- Floodplains. Landfills, land application sites, and lagoons located in floodplain areas may not: restrict the flow of flood waters; reduce the temporary overflow storage capacity of the floodplain in the case of a flood; result in the washout of materials that would present a hazard to humans or wildlife; or contaminate land or water resources.
- Surface Waters. A facility must not discharge pollutants or dredged or fill material into surface waters in violation of provisions of the National Pollutant Discharge Elimination System (Section 402 of the Clean Water Act [CWA]) or of Section 404 of the CWA. Also, nonpoint source pollution of surface waters in violation of a water quality management plan implemented under Section 208 of the CWA is prohibited.
- Ground Water. Landfills, land application sites, and lagoons may not "contaminate an underground drinking water source beyond the solid waste boundary." States have the authority to change the boundaries only if such an alteration would not contaminate drinking water resources.

Regulations in 40 CFR 257 also protect human health by restricting the level of pathogens in sludge disposed on the land. Any sewage sludge applied to or incorporated into the soil must be treated by a Process to Significantly Reduce Pathogens (PSRP) before it is applied to soil (see Table 3-35). This requirement does not apply to the trenching or burial of sludge. Public access to these areas must be restricted for a minimum of 12 months, and

TABLE 3-35

REGULATORY DEFINITION OF PROCESSES TO SIGNIFICANTLY REDUCE PATHOGENS

Aerobic Digestion: The process is conducted by agitating sludge with air or oxygen to maintain aerobic conditions at residence times ranging from 60 days at 15°C to 40 days at 20°C, with a volatile solids reduction of at least 38 percent.

Air Drying: Liquid sludge is allowed to drain and/or dry on underdrained sand beds, or on paved or unpaved basins in which the sludge depth is a maximum of 9 inches. A minimum of 3 months is needed, 2 months of which daily temperatures average above 0°C.

Anaerobic Digestion: The process is conducted in the absence of air at residence times ranging from 60 days at 20°C to 15 days at 35°C to 55°C, with a volatile solids reduction of at least 38 percent.

Composting: Using the within-vessel, static aerated pile, or windrow composting methods, the solid waste is maintained at minimum operating conditions of 40°C for 5 days. For 4 hours during this period, the temperature exceeds 55°C.

Lime Stabilization: Sufficient lime is added to produce a pH of 12 after 2 hours of contact.

Other Methods: Other methods of operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Source: Environmental Regulations and Technology: Use and Disposal of Municipal Wastewater Sludge, Technology Transfer, EPA, September 1984 (EPA 625/10-84-003).

1534S

animals intended for human consumption may not graze this land for a minimum of 1 month. Further, if crops intended for human consumption are to be grown in sludge-amended soil within 18 months of the amending process, the sludge must be treated by a Process to Further Reduce Pathogens (PFRP) before application (see Table 3-36).

Section 257 of RCRA imposes numeric limits on the allowed application rates for cadmium and PCBs on soil that will support food-chain and nonfood-chain crops. Food-chain crops are defined as crops grown for human consumption (including tobacco) and feed for animals whose products are intended for human consumption. The specific requirements are as follows:

- Cadmium. Applications to sites growing tobacco, root crops, and leafy vegetables are limited to 0.5 kilograms per hectare per year (kg/ha/yr). Sites growing other types of crops are limited to 1.25 kg/ha/yr until 1987 when the limit drops to 0.5 kg/ha/yr. Cumulative cadmium applications are limited depending on the pH and cation exchange capacity of the soil. In general, soil pH must be at least 6.5 or greater at the time of planting, and EPA recommends that pH be permanently maintained at or above 6.2. In the case of crops grown exclusively for animal fodder, cadmium is not specifically limited; however, pH must be maintained at or above 6.5. A facility growing animal feed on sludge-amended soil must have an operating plan that outlines measures to ensure against human ingestion of the feed and safeguards public health from the hazards of cadmium entering the food chain.

- PCBs. Sludges containing between 10 and 50 mg/kg of PCBs must be incorporated into the soil when applied to land if the land is to be used to produce animal feed, including pasture crops for animals raised for dairy products. Sludge does not have to be incorporated into soil if PCB concentrations are less than 0.2 mg/kg (actual weight) in the resulting animal feed or less than 1.5 mg/kg (fat based) in the resulting milk.

Once the new regulations governing sewage sludge are finalized, the agency will ammend Part 257.

When PCB levels in sludge exceed 50 mg/kg, sludges fall under the strict requirements of 40 CFR 761. Under these requirements, such sludge may only be incinerated or disposed in a chemical waste landfill. (These regulations fall under the authority of the Toxic Substances Control Act.)

TABLE 3-36

REGULATORY DEFINITION OF PROCESSES TO FURTHER REDUCE PATHOGENS

Composting: Using the within-vessel composting method or the static aerated pile composting method, the solid waste is maintained at operating conditions of 55°C or greater for 3 days. Using the windrow composting method, the solid waste attains a temperature of 55°C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow.

Heat Drying: Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80°C, or the wet bulk temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80°C.

Heat Treatment: Liquid sludge is heated to temperatures of 180°C for 30 minutes.

Thermophilic Aerobic Digestion: Liquid sludge is agitated with air or oxygen to maintain aerobic conditions at residence times of 10 days at 55°C to 60°C, with a volatile solids reduction of at least 38 percent.

Other Methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Any of the processes listed below, if added to a PSRP, further reduce pathogens.

Beta Ray Irradiation: Sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20°C).

Gamma Ray Irradiation: Sludge is irradiated with gamma rays from certain isotopes, such as ^{60}Cobalt and ^{137}Cesium, at dosages of at least 1.0 megarad at room temperature (ca. 20°C).

Pasteurization: Sludge is maintained for at least 30 minutes at a minimum temperature of 70°C.

Other Methods: Other methods or operating conditions may be acceptable if pathogens are reduced to an extent equivalent to the reduction achieved by any of the above add-on methods.

Source: Environmental Regulations and Technology: Use and Disposal of Municipal Wastewater Sludge, Technology Transfer, EPA, September 1984 (EPA 625/10-84-003).

EPA is proposing new regulations (40 CFR 258) pertaining to Subtitle D municipal solid waste landfills. These requirements address monitoring and operating procedures for landfills covered under this subtitle. The impacts of this proposal on the assumptions of baseline sludge disposal practices are discussed in Section Four of this report.

State Regulations

Many states enforce landfilling restrictions through State Subtitle D Programs. There is evidence, however, that the requirements to identify and close or upgrade open dumps under these programs has not been actively enforced by the states. Of 1,209 sites identified as open dumps, 104 are known to accept sewage sludge.[19] Therefore, the sludge going to these open dumps is not controlled by Subtitle D State Program requirements.

A report completed by Booz, Allen, Hamilton, Inc. (BAH) found that 32 states regulate sludge disposal in landfills and 14 govern this option on a case-by-case basis.[20] In most cases, the regulations are not specific to sludge handling; but rather address sludge as one of many substances subject to landfill operating requirements. Two states do not allow disposal of sludge in landfills at all; one does not control disposal of sludge in landfills, and one has only local controls.

The BAH study also indicated that at least 37 states, which control the disposal of sludge in landfills, specified practices for siting relative to ground water and surface water concerns and prohibited siting of landfills in floodplain areas. Thirty-five states have established restrictions on soil type and minimum distance to dwellings as well. A majority of states do or could require the use of liners, gas vents, and runoff control. Only a few states reserve the option to require leachate collection or treatment.

Table 3-37 summarizes selected requirements from landfilling regulations for those states known to contain sludge-only landfills. These existing requirements will be compared to the proposed regulations in Section Four of this report.

TABLE 3-37

SELECTED EXISTING STATE REGULATORY REQUIREMENTS PERTAINING TO LANDFILLING

STATES	REGULATORY REQUIREMENT									
	LANDFILL INSPECTIONS	FLOODPLAIN RESTRICTIONS	RUN-OFF CONTROLS	MAINTENANCE OF CONTROL SYSTEMS	COVER APPLICATION	BUFFER ZONE	SLUDGE QUALITY TESTING	MONITORING WELLS	LEACHATE COLLECTION	REFERENCES
Arizona			Provide drainage to prevent ponding and erosion.		Daily cover required.		Determine whether hazardous.	Monitoring wells required.		PEI, OMPC
Illinois			Controls required.		Daily cover required.		Sludge testing required.	Monitoring wells required.	Leachate collection requirements.	PEI, OMPC
Indiana		Need special permit if in floodplain.	Site-specific requirements.		Daily cover required.	600 feet from nearest dwelling.	EP toxicity test.	Monitoring wells required case-by-case.		PEI, OMPC
Maine		Not allowed in floodplain.	Provide drainage to prevent surface run-off.		Daily cover required.	100 feet from boundary.		Monitoring wells required.		PEI, OMPC
Massachusetts		Not allowed in floodplain except under special circumstances.	Grading and drainage shall minimize run-off/run-on.		Daily cover required.	100 feet from boundary.		Monitoring wells required.	Proposed regulation requires system.	State landfill regulation, PEI

TABLE 3-37 (continued)

	REGULATORY REQUIREMENT									
STATES	LANDFILL INSPECTIONS	FLOODPLAIN RESTRICTIONS	RUN-OFF CONTROLS	MAINTENANCE OF CONTROL SYSTEMS	COVER APPLICATION	BUFFER ZONE	SLUDGE QUALITY TESTING	MONITORING WELLS	LEACHATE COLLECTION	REFERENCES
Missouri		Not allowed in 100-year flood-plain unless diked.	Surface run-off must be controlled.		Daily cover required.		Not in general.	Monitoring wells required.		OMPC, PEI
New Hampshire		Need physical barrier; may not restrict flow, decrease temporary water storage capacity, or cause washout if in 100-year floodplain.	Case-by-case.		Daily cover required.	Case-by-case.		Monitoring wells required.		PEI
Rhode Island		May not restrict flow, decrease temporary water storage capacity, or cause washout if in 100-year floodplain.	Drainage system required to control run-off and run-on and prevent collection of standing water.		Daily cover required.	400 feet from any building not associated with disposal site. 200 feet from boundary.	EP toxicity test required.	Monitoring wells required.		State regulations, PEI.

TABLE 3-37 (continued)

STATES	REGULATORY REQUIREMENT									
	LANDFILL INSPECTIONS	FLOODPLAIN RESTRICTIONS	RUN-OFF CONTROLS	MAINTENANCE OF CONTROL SYSTEMS	COVER APPLICATION	BUFFER ZONE	SLUDGE QUALITY TESTING	MONITORING WELLS	LEACHATE COLLECTION	REFERENCES
Texas		Provide protection for 100-year flood-plain and prevent washout of solid waste.	Run-off controls to minimize contact between water and solid waste.		Daily cover required.	50 feet from boundary.		Monitoring wells required.		State regulations.
Utah[c]										OMPC

[a] Landfilling of sludge is discouraged and excluded by law unless special permission granted.

[b] One site is being proposed; otherwise sludge in landfills is discouraged.

[c] No specific requirements for sludge-only landfills, very little sludge, two POTWs have landfills onsite or close by.

References/Sources:
OMPC: Office of Municipal Pollution Control, EPA, unpublished summary sheets of state regulations pertaining to sewage sludge disposal.
PEI: EPA, State Subtitle D Regulations on Municipal Solid Waste Landfills, Final Draft Report, February 21, 1986, prepared by PEI Associates, Inc.
State regulations: Individual state regulations.

Siting controls pertaining to lagoons or stockpiles are not governed as closely as those for landfills. However, more than half the states have siting requirements similar to those described above for landfills. Fewer states control the use of liners or runoff control measures for this disposal/storage practice.

With respect to land application, a Metcalf and Eddy study completed for EPA Region I reported that 33 states have regulations pertaining to land application of sludge.[21] Thirty-one states set numerical criteria for certain pollutants in terms of maximum loading rates or maximum concentrations allowed in sludge to be land applied. Selected state requirements for land application are summarized in Table 3-38.

In addition to cadmium and PCBs, which are controlled by the federal government, states set limits for at least four other metals, including lead, zinc, copper, and nickel. Most states restrict land application based on plant-available nitrogen loading as well. Thirty states have time limits before crops can be harvested. Pathogen controls to meet at least PSRP are specified in 31 state rules or guidelines. All but a few states require site analysis prior to land spreading, and sludge testing requirements are incorporated in 28 state policies.

3.7.4 Distribution and Marketing

Currently, no federal mandates cover the distribution and marketing (D&M) of municipal sewage sludge. The RCRA requirements in Subtitle C pursuant to land application of sludge could be interpreted to cover D&M. The giveaway or sale of composted sludge has not been regulated specifically under many state land application mandates. Only 11 states have numeric criteria for distribution and marketing separate from land application requirements. Table 3-38 summarizes a number of the current management practices for land application of sewage sludge required by the states. These requirements will be compared to the requirements of the proposed regulation in Section 4.3. The table includes the state sludge testing requirements that apply to distribution and marketing.

TABLE 3-38

SUMMARY OF EXISTING STATE REGULATIONS AND GUIDELINES FOR LAND APPLICATION OF SEWAGE SLUDGE

PROPOSED REQUIREMENTS	STATE REQUIREMENTS												
	AL	AK	AZ	CA	CO	CT	FL	GA	IL	IN	IA	KS	NE
Management Practices													
1. Incorporate sludges into soil for new crops.			X	X	X		X		X		X		
2. Thirty-day waiting period before harvesting or grazing.	X[a]	X[a]	X[a]	X	X	X	X	X	X[a]	X[a]	X		X
3. Soil pH 6.0 or greater.			X	X	c	X	X	X[d]	X	X[e]	X	X	
4. No application on frozen, snow-covered, or flooded lands.		X	X		X	X	X		X				
5. Guidance manual management practices (see codes).	10,11,6	10,6,12, 9	3,4,7, 8,10,6, 14,	State has guidance manual for good practices.	14,6,1, 4,2,16, 5,8,10, 12	1,2,4, 6,12,13, 14,9	3,4,5, 7,10,11, 12,14,9	3,4,5, 6,7,8, 9,12,14	1,2, and 4 may be required; 7,8,10, 11,13	5,8,10, 11,12,9, 14	5,6,8, 11,12	4,5,8, 7,10,6, 9,14	2,3, and 4 may be required; 14,1,5, 8,11,6, 12,13
6. Sludge Testing Parameters.[b]			1 metal and 6 organics not included.	4 metals and 9 organics not included.	1 metal and 9 organics not included.	2 metals not included; volatile-organics required.	4 metals and 10 organics not included.	7 metals and 10 organics are not included.	5 metals and 10 organics not included.	None	2 metals not included; organics on case-by-case basis.	4 metals and 10 organics not included.	2 metals not included; organics cluded.

TABLE 3-38 (CONT.)

PROPOSED REQUIREMENTS	STATE REQUIREMENTS												
	MD	MA	MN	MS	MT	NH	NJ	NY	OH	OR	PA	RI	SC
Management Practices													
1. Incorporate sludges into soil for new crops.	X					X							
2. Thirty-day waiting period before harvesting or grazing.	X	X	X	X		X	X	X	X	X		X	X
3. Soil pH 6.0 or greater.		X	X	X		X	X	X	X	X	X	X	X
4. No application on frozen, snow-covered, or flooded lands.		X				X	X	X			X		
5. Guidance manual management practices (see codes).	3,4,8, 7,12,13, 9,14	4 may be required; 1,5,8, 10,11, 12,13,9, 14	1,5,8, 7,10,11, 15,6,12 13,9,14	2,3, and 4 may be required; 8,7,10, 12,6,14, 9	4 may be required; 1,5,12, 10,15,6, 9	3 and 4 may be required; 1,2,5, 8,7,10, 11,6,12, 14	2 may be required; 1,5,8, 10,11, 15,12, 14	2 and 3 may be required; 1,5,8, 7,10,11, 6,12,9, 13,14	1,3,4 may be required; 5,8,7, 10,11, 15,6,12, 13,14,9	8,7,6, 10,11, 12,9,14	5,7,8, 10,11,6, 12,9,14	1,3,4 may be required; 8,7,10, 11,12,9, 14	4 may be required; 1,5,7,8, 10,11,6, 12,13,9, 14
6. Sludge Testing Parameters.[b]	3 metals and 9 organics not included.	2 metals and 9 organics may not be included.	2 metals and 9 organics not included.	Case-by-case.	None.	2 metals and 10 organics not included.	2 metals and 3 organics not included.	2 metals and 9 organics not included.	4 metals and 10 organics not included.	Unspecified metals must be tested; 10 organics not included.	2 metals and 10 organics not included.	3 metals and 8 organics not included.	5 metals not included; organics required on a case-by-case basis.

TABLE 3-38 (continued)

PROPOSED REQUIREMENTS	STATE REQUIREMENTS						
	TN	TX	VT	VA	WA	WI	WY
Management Practices							
1. Incorporate sludges into soil for new crops.			X				
2. Thirty-day waiting period before harvesting or grazing.	X[a]	X	X	X	X	8	
3. Soil pH 6.0 or greater.	X	X	X	X	X	X	
4. No application on frozen, snow-covered, or flooded lands.			X				
5. Guidance manual management practices (see codes).	3 and 4 may be required; 1,5,7,8, 10,6,12, 9,14	3 or 4 may be required; 1,8,7, 10,11,6, 12,9,14	1,2, and 4 may be required; 8,7,10, 11,6,12, 9,14	2, 3, and 4 may be required; 5,8,7, 15,10, 11,6,12, 13,9,14	2 may be required; 9,1	1,8,7, 10,11, 12,13, 14	7,8,12, 9,14
6. Sludge Testing Parameters.b	3 metals and 10 organics not included.	4 metals and 9 organics are not included.	3 metals not included; other metals and organics may be included on case-by-case basis.	4 metals and 9 organics not included.	Unspecified metals.	10 organics not included.	4 metals and 9 organics not included.

TABLE 3-38 (continued)

PROPOSED REQUIREMENTS	STATE REQUIREMENTS												
	AL	AK	AZ	CA	CO	CT	FL	GA	IL	IN	IA	KS	ME
7. Sludge Sampling Frequency: Land Application.			Required 1/month	<1.0 MGD 2/yr; 1.0-10.0 MGD 4/yr; >10.0 MGD 1/mo	<1 MGD once per 5 years; 1-10 MGD 1/3 yr; > 10 MGD 1/yr	Assume 4/yr	Assume: >1.0 MGD 4/yr; 0-1.0 MGD 1/yr	NA	Assume: >60 MGD 1/mo; 10-60 MGD 4/yr; 0-10 MGD 1/yr	NA	NA	NA	Assume: 1/yr
8. Sludge sampling frequency: D&M.				<1 MGD 2/yr; 1-10 MGD 4/yr; >10 MGD 1/mo	0-10 MGD 1/5 yr; >10 MGD 1/3 yrs yrs				See land application row.				Assume: 1/yr
Recordkeeping and Reporting													
1. Report sludge quality, loading rate, pH of soil, and date of application to state.		Annual records location and volume of waste disposal.	Monthly report to POTW or land owner.	Distributor must record information.	POTW reports every 180 days results of all analyses, amount of sludge applied, location of application.	Application log with application rates, dates, prevailing winds.	Daily log by land operators all information included.	Records must be maintained and submitted to state; all information included.	Sludge user must report to state monthly all information.	Records must be reported to the state as required in permit.			Records with all information must be kept for 5 years.

TABLE 3-38 (CONT.)

PROPOSED REQUIREMENTS	STATE REQUIREMENTS												
	MD	MA	MN	MS	MT	NH	NJ	NY	OH	OR	PA	RI	SC
7. Sludge Sampling Frequency: Land Application.	NA	<1 MGD 2/yr; 1-5 MGD 4/yr; >5 MGD 1/mo	<1 MGD 1/yr; 1-20 MGD 2/yr; >20 MGD 4/yr	NA	NA	<1 MGD 1/yr; >1 MGD 3/yr	Assume: 1/mo	<1 MGD 2/yr; 1-5 MGD 4/yr; >5 MGD 1/mo	Assume: <1 MGD 2/yr; >1 MGD 1/mo	<.5 MGD as required; .5-2 MGD 1/yr; 2-10 MGD 2/yr; >10 MGD 4/yr	NA	Assume: 1/yr	NA
8. Sludge Sampling Frequency: D&M.	NA	<1 MGD 2/yr; 1-5 MGD 4/yr; >5 MGD 1/mo					<25 T/wk 1/2 yr; 25-100 T/wk 4/yr; >100 T/wk 1/mo (dry tons)	<1 T/day 2/yr; 1-10 T/day 1/mo; >10 T/day 1/wk (uncontrolled)	Every 5,000 cy or 1/mo				
Recordkeeping and Reporting													
1. Report sludge quality, loading rate, pH of soil, and date of application to state.	Records kept onsite.	Annual report of all information.	Reports submitted annually with all information.						Site status report and self monitoring reports are required.	Sludge analyses must be available at plant.	Records must be maintained by applicants requiring permits.		Records of all information for each application site.

TABLE 3-38 (continued)

PROPOSED REQUIREMENTS	STATE REQUIREMENTS						
	TN	TX	VT	VA	WA	WI	WY
7. Sludge Sampling Frequency: Land Application.	Assume <1 MGD 1/yr; >1 MGD 2/yr	2/yr for dedicated land.	<1 MGD 1/yr; >1 MGD 2/yr	Assume: <1 MGD 1/2 yr; 1-10 MGD 4/yr; >10 MGD 1/mo	NA	NA	6/yr
8. Sludge Sampling Frequency: D&M.	See Land Application row.	See Land Application row.				NA	
Recordkeeping and Reporting							
1. Report sludge quality, loading rate, pH of soil, and date of application to state.	Annual report of all information.	Maintain records for 3 years.		Records required with all information to state monthly.			

Source: Sludge Compost Marketing and Distribution: Regulatory Requirements in the United States, EPA Region 1, prepared by Metcalf and Eddy, December 1986.

1431S

FOOTNOTES TO TABLE 3-38

[a] No waiting period for harvesting required.

[b] These parameters are compared to numbers of organics and metals required to be tested by the proposed regulation. See Section 4.3 for details about numbers of contaminants to be tested under land application requirements.

[c] Cumulative loading rates given for pH lower than 6.5 as well as greater than 6.5

[d] pH can be lower if cadmium is less than or equal to 2 ppm.

[e] pH can be lower for non-food chain crops on case by case basis.

[f] Non-dairy animals can graze after 2 weeks.

CODES

1. Soil analysis.
2. Crop monitoring.
3. Surface water monitoring.
4. Ground water monitoring.
5. Soil conditions specified.
6. Floodplain restrictions.
7. Buffer zones required.
8. Distances to wells specified.
9. Runoff controls required.
10. Depth to ground water specified.
11. Depth to bedrock specified.
12. Distance to surface water specified.
13. Distance to dry run specified.
14. Slope limits.
15. Permeability specifications.
16. Agronomic rates must not be exceeded.
17. No pollution of surface water or wells allowed.

The U.S. Department of Agriculture (USDA) has published maximum recommended levels for five heavy metals considered suitable for unrestricted distribution of composted wastewater sludge. These recommended levels are voluntary guidelines. The concentrations indicated by USDA are as follows:

- cadmium - 12.5 to 30 mg/kg
- copper - 500 to 900 mg/kg
- nickel - 100 to 200 mg/kg
- zinc - 1,250 to 1,800 mg/kg
- mercury - 5 mg/kg

Some states, including Maryland, have also published recommended levels of pollutants. Other states have no policies on D&M at all. None of the states prohibit D&M.[22]

Of the states that do have controls on D&M, only 11 have limits on heavy metals application rates or PCBs. Seven states restrict the levels of plant-available nitrogen, and 11 states require minimum pathogen control actions.

NOTES TO SECTION THREE

1. The general reference for the descriptions of the wastewater and sludge treatment processes was Wastewater Engineering, Treatment/Disposal/Reuse, Metcalf and Eddy, Inc. Second Edition, McGraw Hill, 1979.

2. U.S. EPA, Use and Disposal of Municipal Wastewater Sludge, September 1984.

3. Ibid (1).

4. Ibid (1).

5. Process Design Manual, Municipal Sludge Landfills, Technology Transfer, U.S. EPA, October 1978, EPA-625/1-78-010.

6. Municipal Waste Combustion Study, Data Gathering Phase, Radian Corporation, October 1986.

7. Municipal Wastewater Sludge Combustion Technology, Seminar Publication, Technology Transfer, EPA, September 1985.

8. U.S. EPA, 1986. Subtitle D Study, Phase I Report. EPA/530-SW-86-054, October 1986.

9. U.S. EPA, 1987. Draft Regulatory Impact Analysis of Proposed Revisions to Subtitle D Criteria for Municipal Solid Waste Landfills. Office of Solid Waste, December 11, 1987.

10. Firstman, Richard C., 1987. Newsday. "High Stake Risk on Incinerators." Dec. 13, 1987.

11. Ibid (8).

12 Westat, 1986, in EPA, 1986, ibid.

13. Ibid (1).

14. Summary of Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methods and Results, EPA, July 1985.

15. U.S. EPA, Construction Costs for Municipal Wastewater Treatment Plants: 1973-1978, April 1980 (430/9-80-003).

16. Handbook for Estimating Sludge Disposal Costs at Municipal Wastewater Treatment Facilities, SCS Engineers, July 1985, (430/9-81-004).

17. NSWMA, 1988. The 1987 Tip Fee Survey: Last Year's Rise Was Biggest Ever. National Solid Wastes Management Association, Technical Bulletin 88-1, January 30, 1988.

18. U.S. EPA, 1987, op cit.

19. Solid Waste Disposal Inventory of Open Dumps, Federal Register, May 29, 1981 (46 FR 29064).

20. A Review of State Programs to Control the Disposal and Utilization of Municipal Sewage Sludge: Implications for the Federal Regulatory Program, EPA Sludge Task Force, Booz, Allen & Hamilton, Inc., March 1983.

21. Sludge Compost Marketing and Distribution: Regulatory Requirements in the United States, EPA Region 1, prepared by Metcalf and Eddy, December 1986.

22. See Notes 20 and 21.

1342S

SECTION FOUR

COSTS AND IMPACTS OF SLUDGE DISPOSAL REGULATIONS

This section estimates the costs and economic impacts associated with the proposed regulations regarding the disposal of sewage sludge. The regulations apply to five disposal practices: incineration; landfilling in sludge-only monofills; land application; distribution and marketing; and surface impoundments. Four regulatory options are presented in this section. These options provide a range of approaches that could be used to establish maximum pollutant concentrations and management practices for the use and disposal of sewage sludge. Each of the regulatory options is described briefly below. Note that the numbering of these options may not exactly correspond to that used in the preamble. To avoid confusion, the reader should focus on the content of each option's requirements when comparing this discussion to that in the preamble.

In Option 1, a sludge failing to pass the Toxicity Characteristic Leaching Procedure (TCLP) - a hazardous waste testing procedure - would be regulated as a hazardous waste under Subtitle C of RCRA. All other sludges would be managed under existing regulations except when limits on lead are exceeded in sewage sludge that is incinerated.

Option 2 sets a cap on the allowable pollutant concentrations in sludge to restrict the use and disposal of sludges that have considerably higher pollutant concentrations than those found in "typical" sewage sludges. These concentrations are derived by determining the 98th percentile concentrations of each contaminant of concern shown in the available EPA database of sludge contaminant levels.

Option 3 is the basis of the proposed sewage sludge regulation. This option, in part, uses risk assessment methodologies to set maximum pollutant concentrations. The setting of maximum concentrations limits risks to individuals when high levels of pollutant exposure are likely to occur or when there are significant scientific uncertainties. The basis for concentration limits for carcinogens is the risk of cancer for the most exposed individual (MEI). These concentrations have been set at levels that achieve a cancer risk of 10^{-5} or 10^{-4} (one cancer in a population of 100,000, or 10,000, respectively), depending on type of disposal method used. For noncarcinogens, an appropriate human health criterion or a plant/animal toxicity value has been selected as a concentration limit. Option 3 also uses the 98th percentile concentrations (as defined above in the description of Option 2) to set pollutant limits for nonagricultural land application and surface impoundments - the disposal methods estimated to have the least impact on human health. In addition, Option 3 requires a number of sludge management practices, including recordkeeping and reporting, that are incremental to Option 1 and 2 requirements.

Option 4 is similar to Option 3 in that the pollutant concentrations are based on risk assessment methodologies. Depending on the sludge disposal method, however, the MEI risk level used in Option 4 is generally more stringent than the risk level in Option 3. Option 4 covers all disposal methods with risk-based requirements; the 98th percentile concentrations are not used to set pollutant concentration limits. Option 4, like Option 3, requires recordkeeping and reporting.

Regulatory Options 1 through 4 are discussed more fully in the following sections. The costs and economic impacts of each of the options for each use and disposal practice are discussed in Sections 4.1 through 4.4 below. Section 4.5 compares the costs and impacts of all options for each use and disposal practice, and Section 4.6 presents the impacts on small entities.

4.1 Costs and Impacts of Regulatory Option 1

Option 1 sets maximum pollutant concentrations at certain specified "TCLP concentrations." Sewage sludges exceeding the proposed TCLP concentrations are considered hazardous and are controlled under Subtitle C of the Resource Conservation and Recovery Act (RCRA). Only four disposal methods -

incineration, monofilling, land application, and distribution and marketing - are covered under Option 1. Surface impoundments are not considered under this option.

In 1985 and 1986, EPA analyzed sludge from 18 POTWs.[1] All sludges passed the proposed TCLP concentrations; thus, EPA estimates that no sewage sludges will fail these criteria. Regulatory Option 1 also includes criteria for certain pollutants in sludge disposed by specific disposal methods: cadmium and PCBs for land application and distribution and marketing; PCBs for monofills; and mercury, beryllium, and lead for sewage sludge incinerator emissions. All but the lead criterion are a part of current regulatory (baseline) requirements.

The lead criterion is proposed for sewage sludge incinerators and has been set to equal 25 percent of the National Ambient Air Quality Standards (NAAQS) for lead following combustion and emission from the incinerator. POTWs using incinerators for disposal of sewage sludge will thus be affected by the requirement to meet the lead criterion.

Sludge testing for organic and inorganic pollutants is also required for all POTWs practicing the four disposal methods covered by the regulation. Pathogen and vector reduction parameter testing is not required, nor are recordkeeping and reporting tasks required. Costs for initial testing to determine whether sludge is hazardous are assumed to be incurred in order to comply with Subtitle C of RCRA, thus no TCLP testing costs are assigned to any of the proposed regulatory options. No incremental impacts other than sludge testing requirements are associated with land application, distribution and marketing and monofills under Option 1. The costs of complying with the lead criterion for POTWs practicing incineration and the sludge testing requirements and costs for all POTWs are presented below.

4.1.1 Costs and Impacts of Regulatory Option 1 Governing the Incineration of Sewage Sludge

The costs and impacts of proposed Option 1 regulations pertaining to sewage sludge incinerators are summarized in this section. POTWs with incinerators must meet a criterion for lead in sewage sludge that will allow their emissions to comply with the Reference Air Criterion for lead of 0.38 micrograms/m^3 (which is 25 percent of the NAAQS for lead). The allowable pollutant concentration is calculated based on the sludge feed rate, a pollution control efficiency assumed for the incinerator, and an air dispersion factor based on the facility's stack height.

Two groups of POTWs are discussed here. The first group, comprising 169 POTWs with 282 incinerators currently incinerates sewage sludge. The second group, 25 POTWs with a projected 34 incinerators, is expected to shift to incineration as a result of the recent legislative ban on the ocean disposal of sludge. At this time, incineration is considered one of the more likely choices for POTWs that must shift from ocean disposal to some other method of disposal. It is not clear, however, that all POTWs will choose this method. Since most of the POTWs have not as yet made even preliminary disposal method selections, the choice of incineration has been used for the purpose of analysis. It is further assumed for this analysis that the compliance costs for this second group of POTWs do not include the costs of shifting from ocean disposal to incineration; rather compliance costs are the difference between the costs of incinerating sewage sludge under a current regulatory scenario and the costs of incinerating sludge under regulatory Option 1. This assumption has been made since the cost of eliminating the ocean disposal of sewage sludge should be credited to the ocean ban legislation, not to any of the sewage sludge regulatory options.

Compliance with the criterion for both groups of POTWs is demonstrated using a two-tiered system. In the first tier, the operator uses a given control efficiency and dispersion factor to calculate the maximum allowable lead concentration in sewage sludge for that incinerator. If the sludge concentrations do not meet the calculated maximum value, compliance must be demonstrated at Tier 2.

Tier 2 involves determining the actual pollutant removal efficiencies of the incinerator and the site-specific air dispersion characteristics. These data are obtained through testing incinerator emissions and conducting computerized air dispersion modeling for each incinerator unit. With these data, more accurate maximum allowable pollutant concentrations are calculated. If a facility has particularly good pollutant removal efficiencies and/or air dispersion characteristics, the maximum allowable pollutant concentrations in sludge calculated at Tier 2 may allow higher levels of pollutants in the sludge than the limits calculated at Tier 1.

For this analysis, a POTW with an existing incinerator is assumed to upgrade the incinerator's pollution control equipment if compliance is not achieved at Tiers 1 or 2. Three retrofit technology options are evaluated in this analysis: (1) installation of wet electrostatic precipitators (ESPs); (2) installation of fabric filters (baghouses); and (3) installation of dry scrubbers in combination with fabric filters. The POTWs that are expected to shift to incineration because of the ocean ban are assumed to have incorporated either fabric filters or wet ESPs into their design plans, either because of existing state regulations because of public pressure or because of the POTWs' awareness that future state and federal regulations may impose more stringent incinerator emission limits than those required by current regulations. New Jersey, in fact, has a considerably more stringent regulation than that embodied by the Option 1 regulatory requirements; the state regulation is slightly more stringent than Option 3 and 4 criteria, as well. Fabric filters or equivalent technology are required by New Jersey on all new sewage sludge incinerators.

The pollutant removal efficiencies for the three control technologies listed above are not well documented for sewage sludge incinerators. For this reason, it cannot be stated with complete certainty that any of these pollution control technologies would bring an incineration unit into compliance with the criterion, although these devices have been shown to improve removal efficiencies significantly on other types of incinerators. While acknowledging the limitations of the data, the analysis assumes sufficient removal of pollutants are attained using one of the three types of control technology. The expected removal efficiency for lead for each type of control option is discussed in Section 4.1.1.3.

Under regulatory Option 1, POTWs are not required to implement any minimum operating practices (such as monitoring). The option does specify, however, that sludge testing be performed annually for POTWs processing less than 1 MGD; quarterly for those processing 1 to 10 MGD; and monthly for those processing more than 10 MGD.

4.1.1.1 Methodology

Compliance costs for each group of POTWs (those currently incinerating sewage sludge and those expected to incinerate sewage sludge as a result of the ocean ban) have been estimated using two similar methodologies. For both groups, compliance costs were estimated using a two-stage process. First, a pass/fail analysis was performed to determine the number of facilities currently in compliance with the proposed criteria at both Tier 1 and Tier 2. Second, compliance costs were aggregated for sludge testing, incinerator performance tests, and pollution control systems.

The three sludge contaminant profiles presented in Section Three (representing typical sludges, 90th percentile sludges, and 98th percentile sludges) formed the basis for comparison to the criteria for both groups of POTWs. In addition, 10 actual incineration facilities were chosen as models (i.e., they were used to define model facility categories) to represent relevant characteristics of all incineration facilities. Each of the existing POTWs with incinerators was assigned to one of the 10 model facility categories based on similarities in incinerator capacity, urban/rural location, and stack height (where this information was known). The relevant characteristics of the 10 model facilities and the number of existing facilities assigned to each model category are presented in Tables 4-1 and 4-2. The number of POTWs and incinerators expected to incinerate sludge as a result of the ocean ban have been assigned to the model facility categories as well. Table 4-3 presents these assignments. Because some ocean ban POTWs are assumed to design centralized facilities, the number of incineration facilities, as well as the number of POTWs and number of incineration units, is presented in this table.

TABLE 4-1

RELEVANT PARAMETERS FOR THE TEN MODEL SLUDGE INCINERATION FACILITIES

MODEL FACILITY CATEGORY	LOCATION	INCIN-ERATOR TYPE	NUMBER OF INCINER-ATORS	TOTAL CAPACITY (DRY METRIC TONS/DAY)	STACK HEIGHT (METERS)	STACK DIAMETER (METERS)	STACK TEMP. (°K)	STACK VELOCITY (METERS/SEC.)	STACK FLOW (ACMS)	LAND USE	BUILDING DIMENSIONS (METERS)			DISPERSION FACTOR (MEI) (ug/m³/g/sec)
											HEIGHT	LENGTH	WIDTH	
1	Arlington, VA	MH	2	31.6	35.4	0.91	338	14.0	9.02	Urban	18.3	26.5	33.9	1.7
2	Gainesville, GA	Elect.	2	10.0	7.6	0.51	311	7.70	1.61	Rural	5.5	31.7	23.5	39.4
3	Dubuque, IA	FB	2	13.6	16.2	0.61	308	11.83	3.45	Rural	10.7	54.9	54.9	26.7
4	Patapsco, Baltimore	MH	3	89.4	21.8	0.91	308	7.70	5.11	Urban	16.3	54.9	14.1	6.87
5	Detroit, MI	MH	14	982.0	22.0[a] 44.0	1.32	310[a] 307	14.3 15.7	19.6 21.5	Urban	29	82.0	62.0	1.35
6	Cincinnati, OH	MH	4	153.1	23.3	0.8	325	20	10.12	Urban	18.3	73.2	55.5	3.69
7	Cleveland, Westerly	MH	4	176.7	27.4	0.91	308	18.98	12.46	Urban	25.0	48.0	48.0	4.01
8	Greenbay, WI	MH	2	79.5	55.1	1.52	329	11.3	20.5	Urban	18.3	36.6	36.6	5.39
9	Rocky Mount, NC	MH	1	9.4	18.3	0.58	308	9.31	2.46	Rural	15.3	15.1	8.5	12
10	Port Washington, NY	FB	1	25.3	9.2	0.46	308	10.10	1.66	Urban	6.8	29.3	28.5	9.08

[a] Complex I and Complex II at Detroit.

Note: MH = Multiple hearth; FB = Fluid bed; Elect. = Electric.

TABLE 4-2

NUMBER OF EXISTING POTWS WITH INCINERATORS IN EACH MODEL FACILITY CATEGORY

MODEL FACILITY CATEGORY	TYPICAL SLUDGE		90TH PERCENTILE SLUDGE		98TH PERCENTILE SLUDGE		TOTAL	
	NUMBER OF POTWS	NUMBER OF INCINERATOR UNITS	NUMBER OF POTWS	NUMBER OF INCINERATOR UNITS	NUMBER OF POTWS	NUMBER OF INCINERATOR UNITS	NUMBER OF POTWS	NUMBER OF INCINERATOR UNITS
1	47	63	0	0	0	0	47	63
2	6	9	3	4	0	0	9	13
3	15	20	13	16	0	0	28	36
4	7	14	2	3	0	0	9	17
5	1	3	1	14	0	0	2	17
6	4	9	18	29	4	5	26	43
7	26	46	5	12	0	0	31	58
8	0	0	4	14	1	2	5	16
9	0	0	2	3	4	5	6	8
10	3	7	3	4	0	0	6	11
Total	109	171	51	99	9	12	169	282

Source: ERG estimates.

2048S

TABLE 4-3

NUMBER OF POTWS ESTIMATED TO CONSTRUCT INCINERATORS UNDER THE REQUIREMENTS OF THE OCEAN BAN ON SEWAGE SLUDGE DISPOSAL BY MODEL FACILITY CATEGORY

	TYPICAL SLUDGE			90TH PERCENTILE SLUDGE		
MODEL FACILITY	NO. OF POTWs	NO. OF FACILITIES	NO. OF UNITS	NO. OF POTWs	NO. OF FACILITIES	NO. OF UNITS
1	3	3	8	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	1	1	1	0	0	0
5	0	0	0	0	0	0
6	15[a]	3[a]	9[a]	0	0	0
7	0	0	0	0	0	0
8	2	2	5	4	2	11
9	0	0	0	0	0	0
10	0	0	0	0	0	0
Total	21	9	23	4	2	11

[a] Seven POTWs are expected to be served by one central facility on Long Island. Of these, one is estimated to generate 90th percentile sludge. Since such a small percentage of the sludge expected to be incinerated at this facility is considered to be 90th percentile sludge, all the Long Island POTWs, their facility and their incinerators have been counted in the typical sludge columns.

Source: ERG and Abt Associates estimates.

A number of assumptions were made in order to predict the number of facilities and incinerators that might be constructed as a result of the ocean ban. The legislation banning ocean disposal is so new that the POTWs themselves are not certain of the type or number of incinerators they may construct. Therefore a scenario, which defines only one possible set of decisions, was constructed. This scenario is used as an example of what might occur; the incremental costs estimated using this scenario are only very rough approximations of the costs that may actually be incurred.

The ocean ban scenario is defined as follows: the Long Island POTWs, which tend to be smaller than the average ocean disposing POTW and which are located near each other, are assumed to build one central facility. The four POTWs in Queens and the four POTWs in Brooklyn are also assumed to build central facilities. Finally, the three smallest POTWs in New Jersey are also assumed to build central facilities as well. At this time, there is no way to determine whether these POTWs will, in fact, group themselves in this manner, although there are a number of economic and logistic factors that may encourage some cooperation among nearby POTWs to construct central facilities.

Based on the POTWs which were assumed to make use of each facility, the quantity of sludge expected to be incinerated at each facility could be determined. The number of incineration units needed to process this quantity of sludge were then derived based on the capacities of units in each of the model facilities. All units were assumed to be fluid-bed incinerators. New Jersey POTWs are not actively considering any other types of incinerator, and New York POTWs are assumed to be using similar considerations in their planning.

For both groups of POTWs, the 10 model facilities and the sludge quality profiles are used along with a given control efficiency, dispersion factors, and a Reference Air Criterion for lead to determine which facilities would pass at Tier 1. Facilities estimated to fail at Tier 1 are assumed to perform emissions testing and air modeling in an attempt to demonstrate compliance at Tier 2. At Tier 1, the regulation requires maximum pollutant concentrations to be computed based on reasonable worst-case control efficiencies (defined as 10th percentile efficiencies derived in an ongoing study of incinerator control efficiencies[2]), which are specified in the regulation. Thus many POTWs are anticipated to show improved incinerator control efficiencies at Tier 2.

To approximate the actual control efficiencies that might be measured at Tier 2, the Tier 2 pass/fail analysis uses the 25th percentile efficiencies that were estimated in the same study of incinerator control efficiencies rather than the 10th percentile control efficiencies used by the option. Additionally, dispersion factors at Tier 1 are provided by a table in the regulation. At Tier 2, dispersion factors for the model facilities are derived by running air dispersion models for each site location using site-specific factors. Dispersion factors are calculated in this manner to approximate the greater accuracy achieved when dispersion is modeled at Tier 2. Compliance at Tier 2 for the facilities represented by these models cannot be estimated precisely, however, since calculations of dispersion factors depend on detailed site-specific factors that would be different from those at the model facilities. In the absence of site-specific data, it is assumed that all POTWs currently incinerating sludge that fail at Tier 2 (after maximum contaminant levels are calculated using 25th percentile control efficiencies and more precise dispersion factors) would incur the costs of retrofit controls. The ocean-ban POTWs, however, are assumed to pass at Tier 2, regardless of their model facility assignment due to the assumption that they would have fabric filters or wet ESPs in place.

4.1.1.2 Results

The results of the Tier 1 pass/fail analysis are presented in Table 4-4. The maximum allowable lead concentration in the sludge calculated for each model category is presented. These values are compared to the estimated lead concentrations in each of the three sludge profiles. If the estimated concentration for lead exceeds the calculated maximum allowable lead concentration, the model facility fails to demonstrate compliance at Tier 1.

TABLE 4-4

TIER 1 PASS/FAIL ANALYSIS FOR INCINERATORS UNDER OPTION 1

MODEL FACILITY	MAXIMUM ALLOWABLE LEAD CONCENTRATION (MG/KG)	PASS/FAIL[a]		
		TYPICAL	90TH PERCENTILE	98TH PERCENTILE
1	358.6	P	P	P
2	175.8	P	P	P
3	220.1	P	P	P
4	75.3	P	P	P
5	6.9	P	P	P
6	54.2	P	P	P
7	51.5	P	P	P
8	231.8	P	P	P
9	409.0	P	P	P
10	70.2	P	P	P

[a] Based on a lead concentration of 265.741 mg/kg for a typical sludge concentration, 821.87 mg/kg for 90th percentile sludge and 1,622.8 mg/kg for 98th percentile sludge.

2045S

As the table shows, only two model facilities (Nos. 1 and 9) pass the criteria when typical sludge is incinerated at Tier 1. For POTWs that currently incinerate sludge, these two model facilities represent a total of 47 POTWs and 63 incinerators. All other model facilities currently incinerating typical sludges and all model facilities currently incinerating 90th and 98th percentile sludges (for a total of 122 POTWs and 219 incinerators) fail to meet the lead criterion at Tier 1. Thus, these 122 facilities failing the lead criterion at Tier 1 will try to show compliance at Tier 2. Three ocean ban POTWs pass the Tier 1 criteria, since they have been assigned to Model Facility 1. The 22 ocean ban POTWs that do not pass at Tier 1 will also have to show compliance at Tier 2.

The results of the Tier 2 pass/fail analysis are presented in Table 4-5. When 25th percentile control efficiencies are assumed and when dispersion factors are calculated rather than taken from the table in the regulation, four model facilities (Nos. 4, 5, 6, and 7) fail the lead requirement when incinerating typical profile sludge. These model facilities represent 38 POTWs with 72 existing incinerators. When 90th percentile sludge is incinerated, all but two model facilities (Nos. 1 and 9) fail the criterion. The failing model facilities represent an additional 49 POTWs with 96 existing incinerators. When 98th percentile sludge is incinerated all but one model facility (No. 1) fail the lead criterion. This is an additional 9 POTWs with 12 existing incinerators. Thus a total of 96 POTWs with 180 existing incinerators are estimated to fail the lead criterion at Tier 2 and will incur retrofit costs. As discussed above, all ocean ban POTWs are assumed to have wet ESPs or fabric filters in place, thus all are expected to pass the lead criterion at Tier 2.

4.1.1.3 Compliance Costs

Compliance costs include the costs of sewage sludge testing, incinerator performance tests, and retrofit control technologies, when these retrofits are necessary to comply with the emission requirements embodied in the regulation.

TABLE 4-5

TIER 2 PASS/FAIL ANALYSIS FOR INCINERATORS UNDER OPTION 1

MODEL FACILITY	MAXIMUM ALLOWABLE LEAD CONCENTRATION (MG/KG)	PASS/FAIL[a]		
		TYPICAL	90TH PERCENTILE	98TH PERCENTILE
1	2,658.4	P	P	P
2	362.5	P	F	F
3	393.3	P	F	F
4	232.5	F	F	F
5	107.7	F	F	F
6	252.8	F	F	F
7	201.5	F	F	F
8	333.3	P	F	F
9	1,266.0	P	P	F
10	621.7	P	F	F

[a] Based on a lead concentration of 265.741 mg/kg for a typical sludge concentration, 821.87 mg/kg for 90th percentile sludge and 1,622.8 mg/kg for 98th percentile sludge.

Costs of Sewage Sludge Testing

Most POTWs very likely perform some sludge testing of common heavy metals (e.g., cadmium or chromium), but the extent of current testing among POTWs with sludge incinerators has not been documented. No federal regulations address this practice, and EPA is unaware of such requirements among the states. New Jersey POTWs will be required to test their sludge during the emission characterization phase of permitting, but no regular testing of sludge quality appears to be required. It was assumed conservatively that all sludge testing performed to comply with Option 1 requirements would be entirely new activity for both groups of POTWs. Actual testing costs may be overestimated because baseline sludge testing is not accounted for. This overestimation, however, is judged to be small.

Sludge testing costs were derived based on the average charges to obtain sludge testing services at independent testing laboratories. These charges averaged $15 per metal and are applied to tests for seven metals (six metals are regulated under the TCLP criteria, and one metal, beryllium, under NESHAPS). Specific organic analyses are not required. Some POTWs may have in-house laboratories capable of providing needed testing services at a lower cost. The total annual cost of sludge testing for all POTWs with existing and anticipated incinerators is presented in Table 4-6. The estimated annual sludge testing costs are $176,505.

Emissions Performance Tests and Air Dispersion Modeling

If POTWs incinerating sludge do not pass the Tier 1 criteria, they are assumed to conduct an emissions performance test and air dispersion modeling. At the time of the performance test, the sludge contaminant levels must be determined and other relevant operating conditions, such as sludge feed rate and combustion temperatures, must be recorded. The POTWs must then assemble the data and prepare a report of the performance test results. The ocean ban POTWs are assumed to have performed this testing as a part of their initial permitting requirements. New Jersey POTWs are required to demonstrate that

TABLE 4-6

ANNUAL SEWAGE SLUDGE TESTING COSTS FOR POTWs PRACTICING INCINERATION UNDER OPTION 1

($1987)

SIZE	NO. OF EXISTING POTWS	OCEAN BAN POTWS	FREQUENCY	TESTING COST/ POTW/YR	TOTAL COST
0.1 MGD	0	0	1/yr	$ 105	$ 0
0.5 MGD	3	2	1/yr	105	525
2 MGD	71	3	4/yr	420	31,080
14 MGD	76	6	1/mo	1,260	103,320
128 MGD	19	14	1/mo	1,260	41,580
Total	169	25			$176,505

Source: ERG estimates.

their emissions do not result in cancer risks exceeding 10^{-5} beyond the facility boundaries. In order to demonstrate this, some form of emission testing and dispersion modeling must be performed. New York POTWs are assumed to perform the same types of tests either because of potential regulatory requirements or public pressure. As such, no incremental costs for emissions testing or dispersion modeling are assumed for these POTWS.

Table 4-7 summarizes the aggregate costs of emissions performance testing and air dispersion modeling. Although the performance testing and dispersion modeling are costly, it is assumed that a POTW will attempt to demonstrate compliance at this stage before installing expensive retrofit pollution control equipment. The assumptions regarding the incremental costs of emissions performance testing per facility are as follows:

- Sludge testing during emissions testing is assumed to be incorporated as part of the POTW's regular sludge testing schedule. Thus, no testing cost incremental to those presented in Table 4-5 are assumed.
- Emission tests for lead must be conducted by all facilities failing to meet the lead criterion at Tier 1. Most of the cost of emissions testing is associated with stack sampling. The cost is approximately the same whether one or seven metals are analyzed. One incinerator test for metals (including costs for sampling, analysis, and report preparation) averages about $11,400, based on discussions with companies providing this service. Costs for testing additional incinerators (where a POTW has more than one in operation) would add an average of $1300 per incinerator for metals analysis. It is also assumed that 2 additional days with a 2-person crew would be required to complete the additional sampling on each incinerator at an average of about $400/day/person or $1600. An added $600/incinerator for report preparation by the stack sampling firm is also assumed. Thus a total of $3500 per additional incinerator is estimated to be incurred.
- Costs associated with supervision of the emissions testing, data assembly, and additional report writing are based on 24 hours of the assistant superintendent of the POTWs' time and 8 hours of clerical staff time. Hourly labor rates are $14.46 for the assistant superintendent and $10.00 for clerical staff for a total of $431 per POTW.

Dispersion modeling for each facility is conducted by an air modeling consultant at a cost of $1,000 for modeling one incinerator, which accounts for 16 hours of work at approximately $60 per hour.

TABLE 4-7

AGGREGATE COSTS OF INCINERATOR PERFORMANCE TESTING UNDER OPTION 1

($1987)

	NO. OF POTWS[a]	NO. OF INCINER-ATORS[a]	EMISSION TESTING COSTS FOR ONE INCINERATOR	EMISSION TESTING COSTS FOR ADDITIONAL INCINERATORS	DISPERSION MODELING COST	TOTAL SUPERVISION, DATA ASSEMBLY & REEPORTING	TOTAL COSTS FOR PERFORMANCE TESTS AND DISPERSION MODELING
0.1 MGD	0	0	$ 0	$ 0	$ 0	$ 0	$ 0
0.5 MGD	2	2	22,800	0	2,000	862	25,662
2 MGD	47	59	535,800	42,000	47,000	20,257	645,057
14 MGD	56	91	638,400	122,500	56,000	24,136	841,036
128 MGD	17	67	193,800	175,000	17,000	7,327	393,127
Total	122	219	$1,390,800	$339,500	$122,000	$ 52,582	$1,904,882

[a] As the text notes, 47 POTWs with 63 existing incinerators pass the criteria at Tier 1. These POTWs will not have to test incinerator performance at Tier 2. The ocean ban POTWs are assumed to test their incinerators as part of their baseline permit requirements.

Source: ERG estimates.

2063S

Total costs associated with the performance testing to demonstrate compliance at Tier 2 by POTWs with existing incinerators are $1.9 million. These costs are one-time expenditures incurred by all POTWs in this group that fail at Tier 1 and that want to avoid the cost of retrofit pollution control devices.

Control Technology Options

POTWs with existing incinerators that fail to meet the lead criterion following performance testing and dispersion modeling are expected to install additional pollution control equipment. The three pollution control devices that will most likely be considered for retrofitting - wet electrostatic precipitators (ESPs), fabric filters, and dry scrubbers with fabric filters - are discussed below.

Most operating sewage sludge incinerators employ some type of wet scrubbing device to control particulate emissions. Particulate removal efficiencies can be improved through the use of wet ESPs and fabric filters. Although the dry scrubbing system is designed to remove acids from incinerator gases, this system also efficiently removes organic pollutants and particulates in solid-waste incineration applications.

Wet ESPs efficiently remove particulates from incinerator flue gases. These devices operate by electrically charging the particles in the gases as they flow through a chamber. Oppositely charged plates or tubes attract and collect the particles. The particles are periodically washed off the collection plates and gathered by an ash slurry system.

Fabric filters can attain very high removal efficiencies of fine particulates from flue gases. These devices use a porous glass fabric that traps particulates as the gases pass through a series of suspended fabric filter tubes. The collected particulates are periodically shaken from the fabric for accumulation and removal from the bottom of the apparatus.

Dry scrubbers, also called spray dryer acid gas removal systems, remove acids from waste combustors. Lime is added to the gases to neutralize the acids, and the fabric filter collects the lime and other particles before the gases leave the stack. (The first sewage sludge incinerator with a dry scrubber and fabric filter system has been designed for a POTW in California and should soon be operational.)

Figures 4-1 through 4-7 illustrate simplified schematics of existing multiple-hearth or fluid-bed incinerators and the various technology retrofit options scenarios. Figure 4-1 depicts a typical existing multiple-hearth installation. The incineration unit is followed by a venturi scrubber and impingement-plate aftercooler (this is currently the most common scrubber configuration, but other scrubber types can be substituted in the diagrams). The configuration depicted in Figure 4-1 is also typical of electric furnaces.

As shown in the figure, the gas leaves the incinerator at 700°F. It passes through the venturi and aftercooler, where it is cooled to 120° F. (Aftercoolers are commonly used in incinerator installations because cooled gases do not create a white plume when released to the atmosphere.) The gas is then pulled out of the stack by the induced-draft fan.

Figure 4-2 depicts the installation of a fabric filter on a multiple-hearth or electric furnace. A venturi cannot be used in this system because it adds a large amount of moisture. Gases that are too wet will cake the filter material. Thus, a quench chamber, which uses less water than a venturi, cools the gases for entry to the fabric filter. The aftercooler follows the fabric filter for further cooling before the gases leave the stack. (If operating temperatures are high, it is more economical in a fabric filter retrofit to reinstall the aftercooler and keep the existing fan, rather than to omit the aftercooler and replace the fan with a bigger fan.)

When a wet ESP is used on a multiple-hearth or electric furnace (Figure 4-3), a venturi can be installed. Therefore, the venturi section can either remain for added particulate removal or be dismantled, if desired. The manufacturers of wet ESP systems recommend that coarse particles be removed

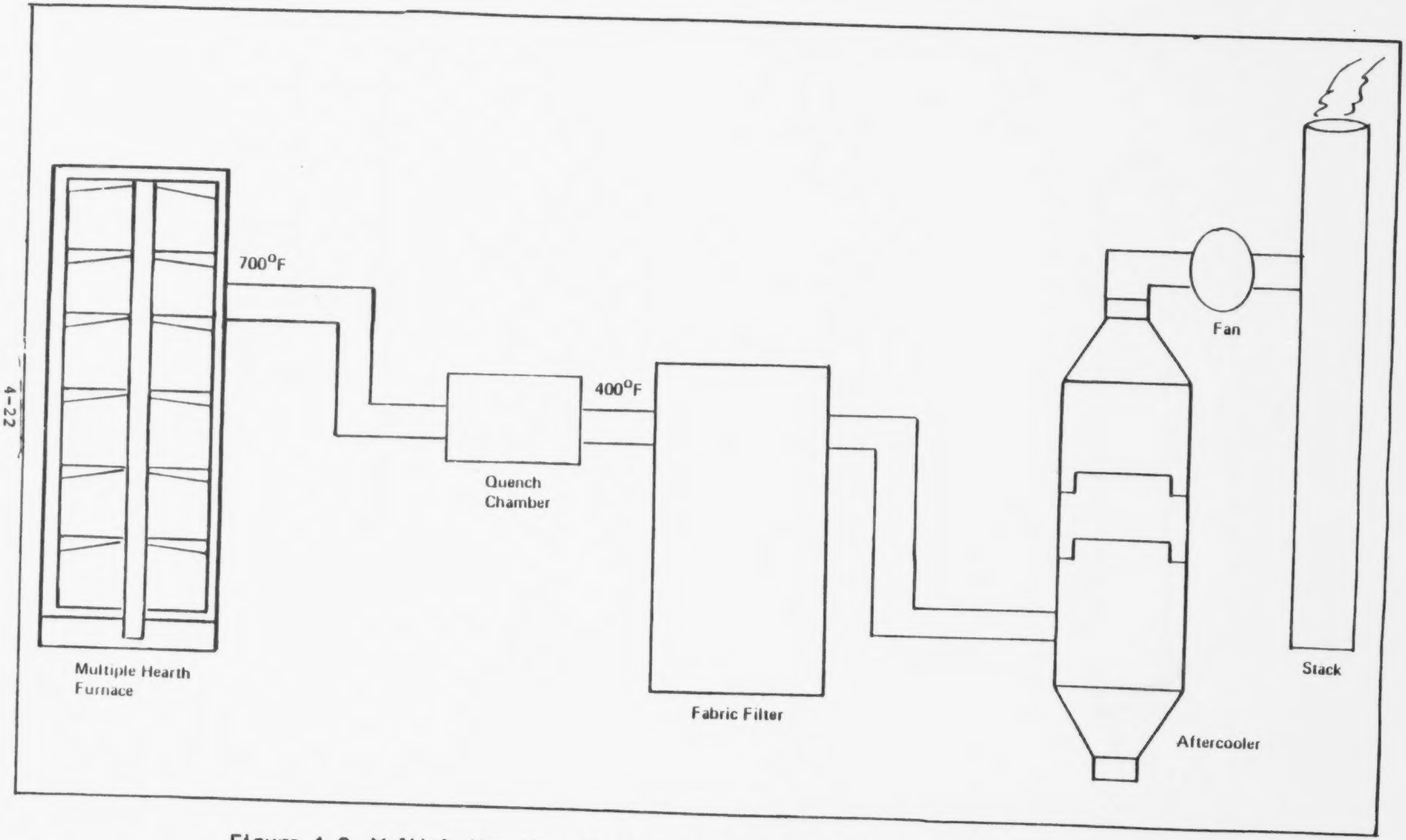

Multiple Hearth Furnace
700°F
Quench Chamber
400°F
Fabric Filter
Aftercooler
Fan
Stack

Figure 4-2. Multiple-Hearth or Electric Furnace Retrofit Scenario with Fabric Filter.

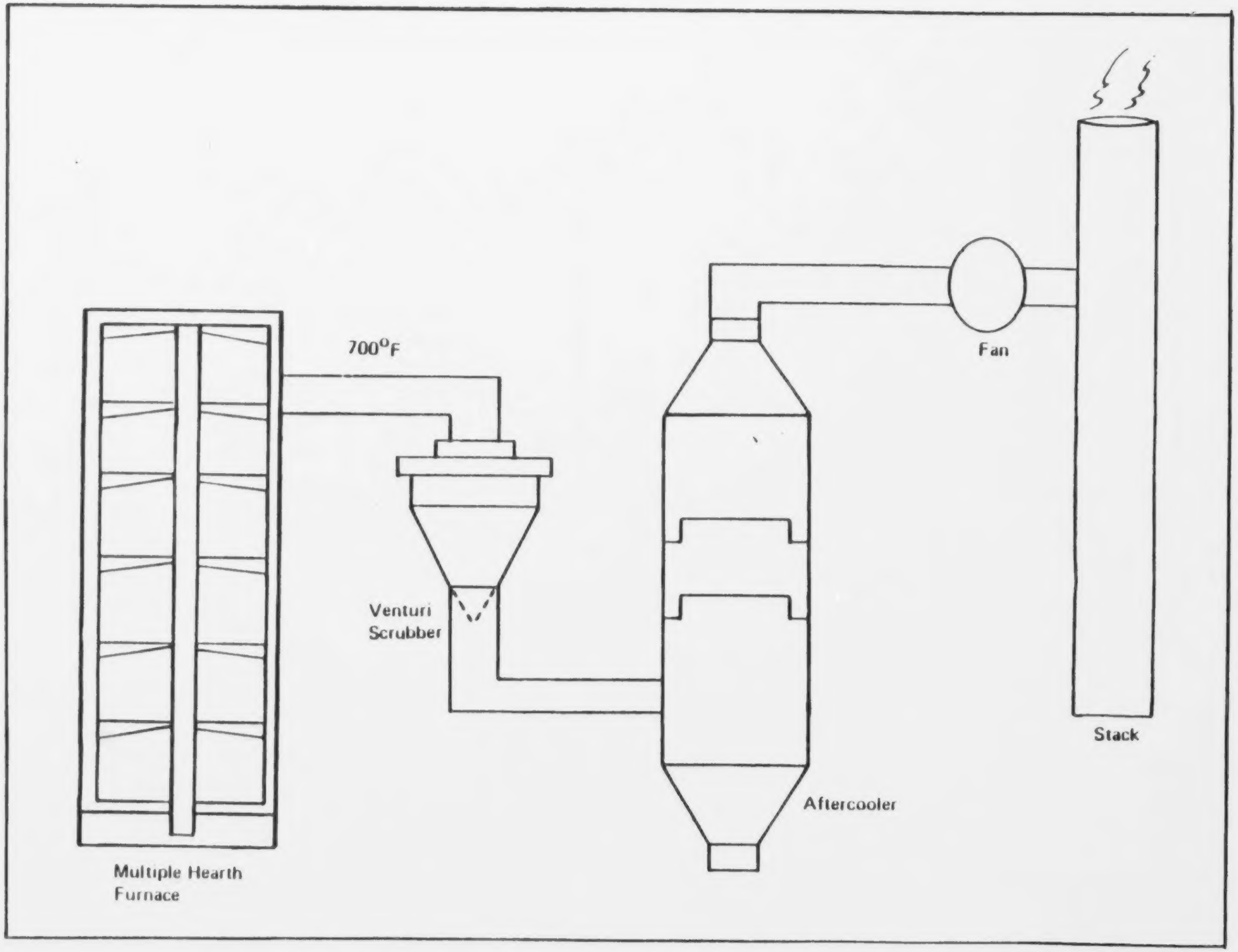

700°F
Fan
Venturi Scrubber
Stack
Aftercooler
Multiple Hearth Furnace

Figure 4-1. Multiple-Hearth or Electric Incinerator - Existing Configuration.

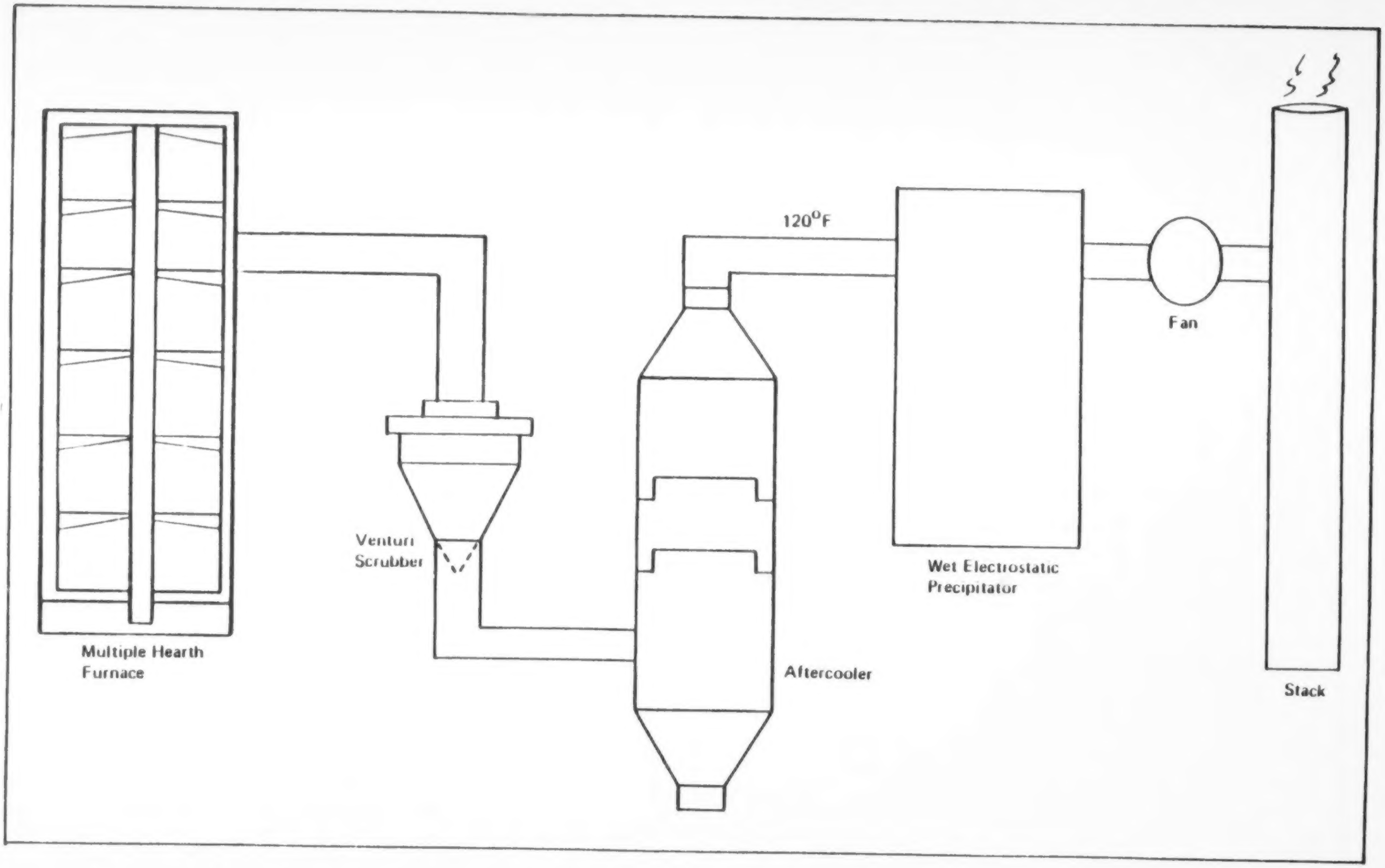

120°F
Fan
Multiple Hearth
Furnace
Venturi
Scrubber
Aftercooler
Wet Electrostatic
Precipitator
Stack

Figure 4-3. Multiple-Hearth or Electric Furnace Retrofit Scenario Wet Electrostatic Precipitators.
Note: Venturi Scrubber May Be Removed If Desired For This Installation.

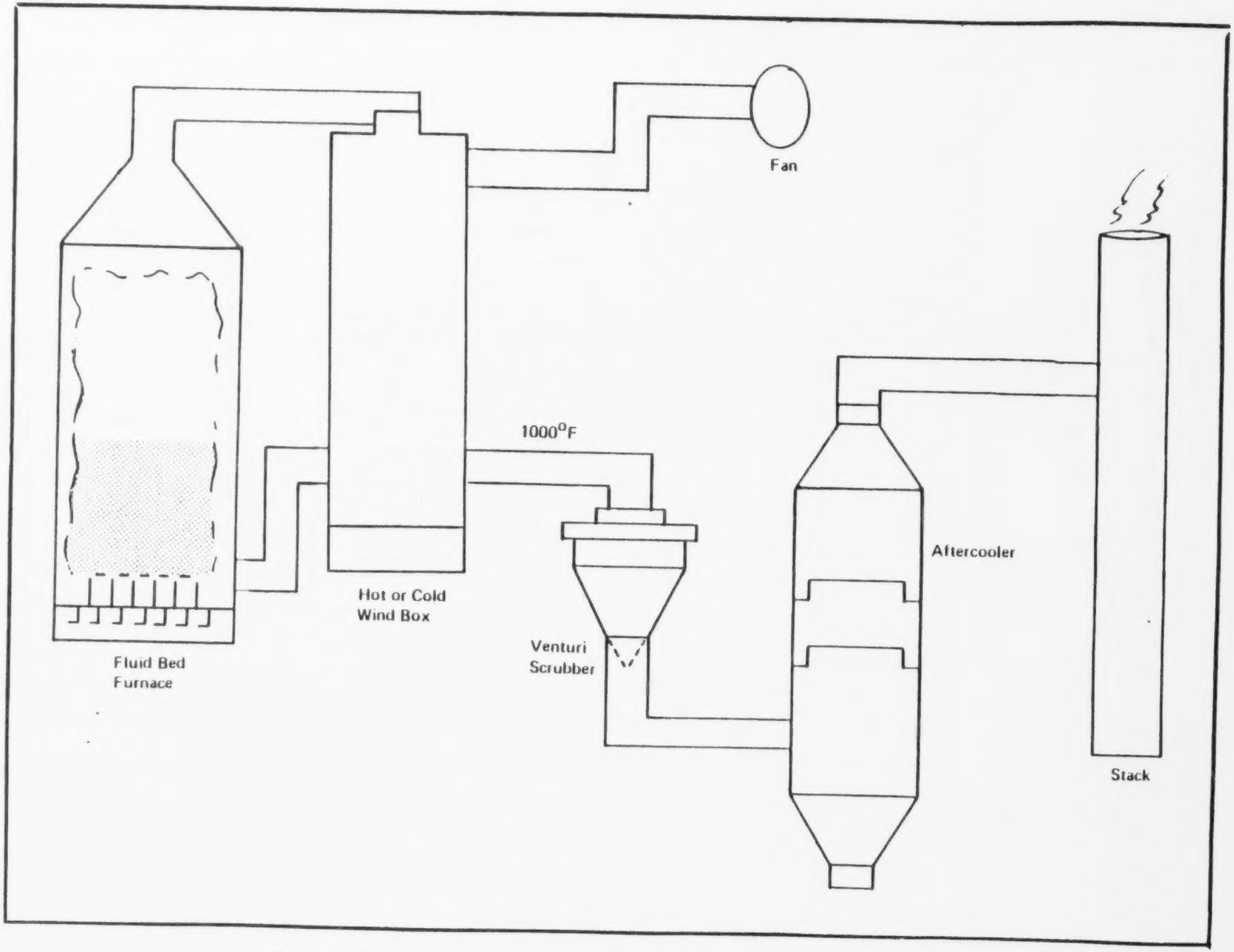

Fan
1000°F
Fluid Bed Furnace
Hot or Cold Wind Box
Venturi Scrubber
Aftercooler
Stack

Figure 4-4. Fluid-Bed Incinerator - Existing Configuration

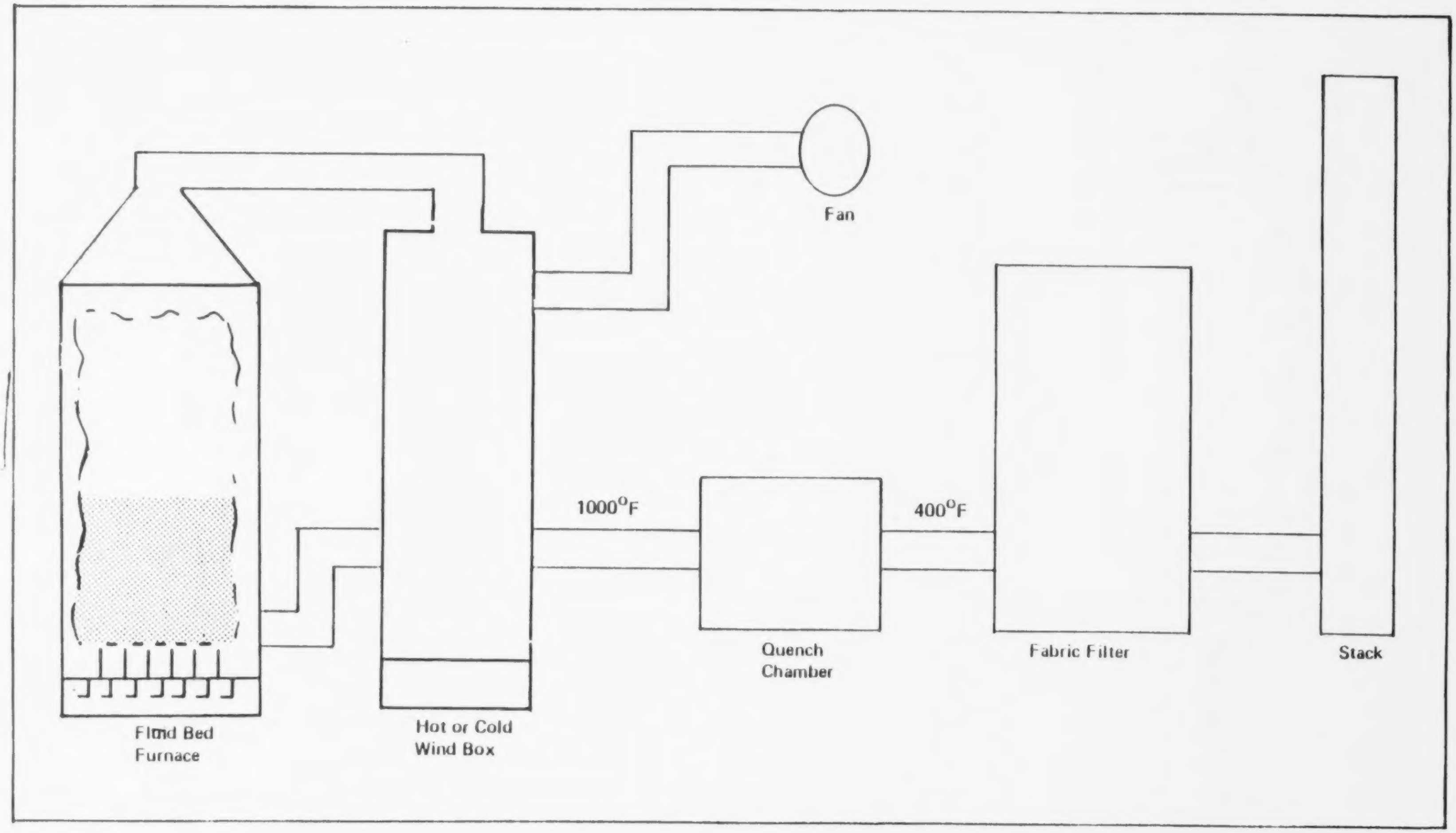

Fan
Fluid Bed
Furnace
Hot or Cold
Wind Box
1000°F
Quench
Chamber
400°F
Fabric Filter
Stack

Figure 4-5. Fluid-Bed Incinerator Retrofit Scenario - Fabric Filter.

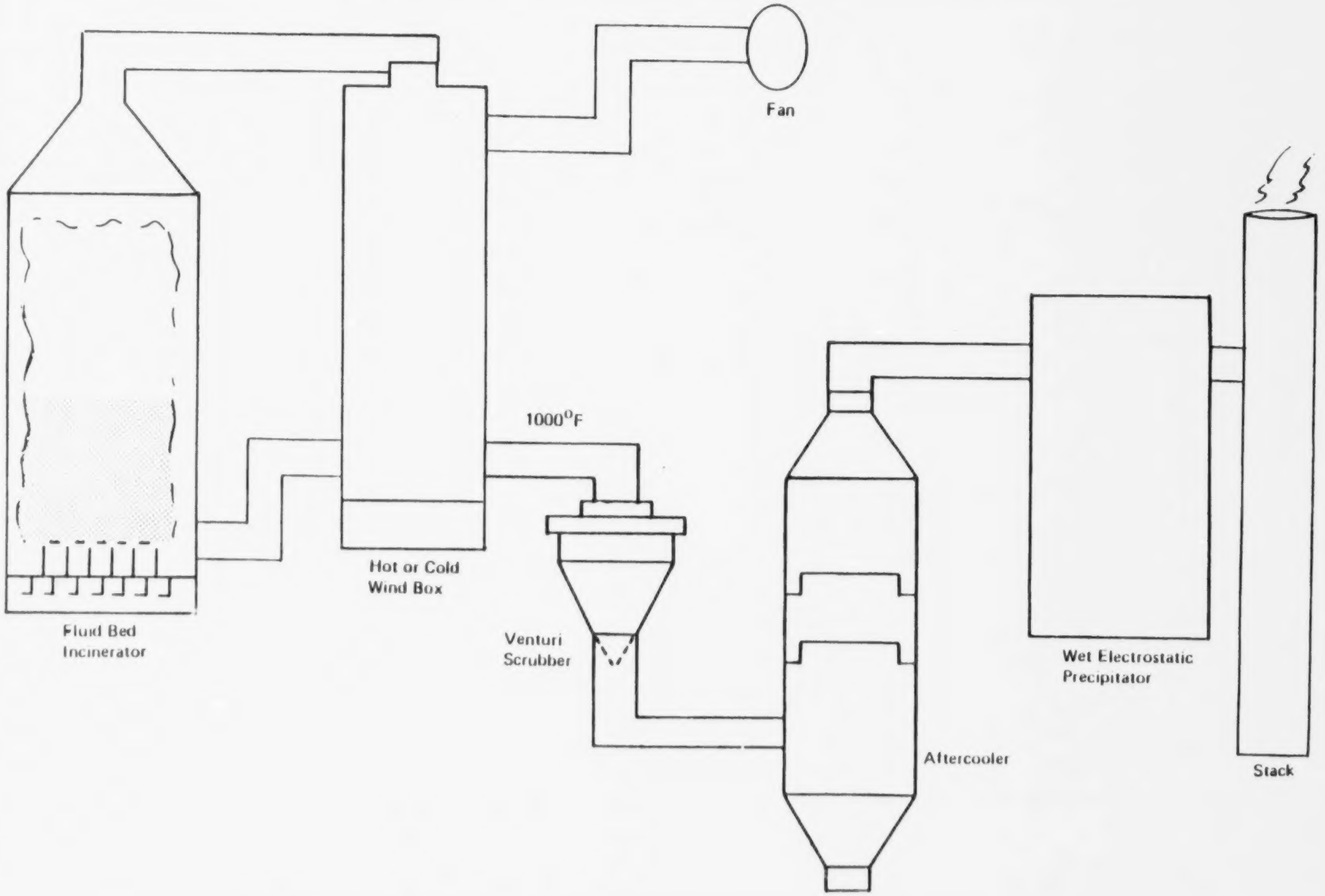

Fan
1000°F
Fluid Bed Incinerator
Hot or Cold Wind Box
Venturi Scrubber
Aftercooler
Wet Electrostatic Precipitator
Stack

Figure 4-6. Fluid-Bed Incinerator Retrofit Scenario - Wet Electrostatic Precipitator.

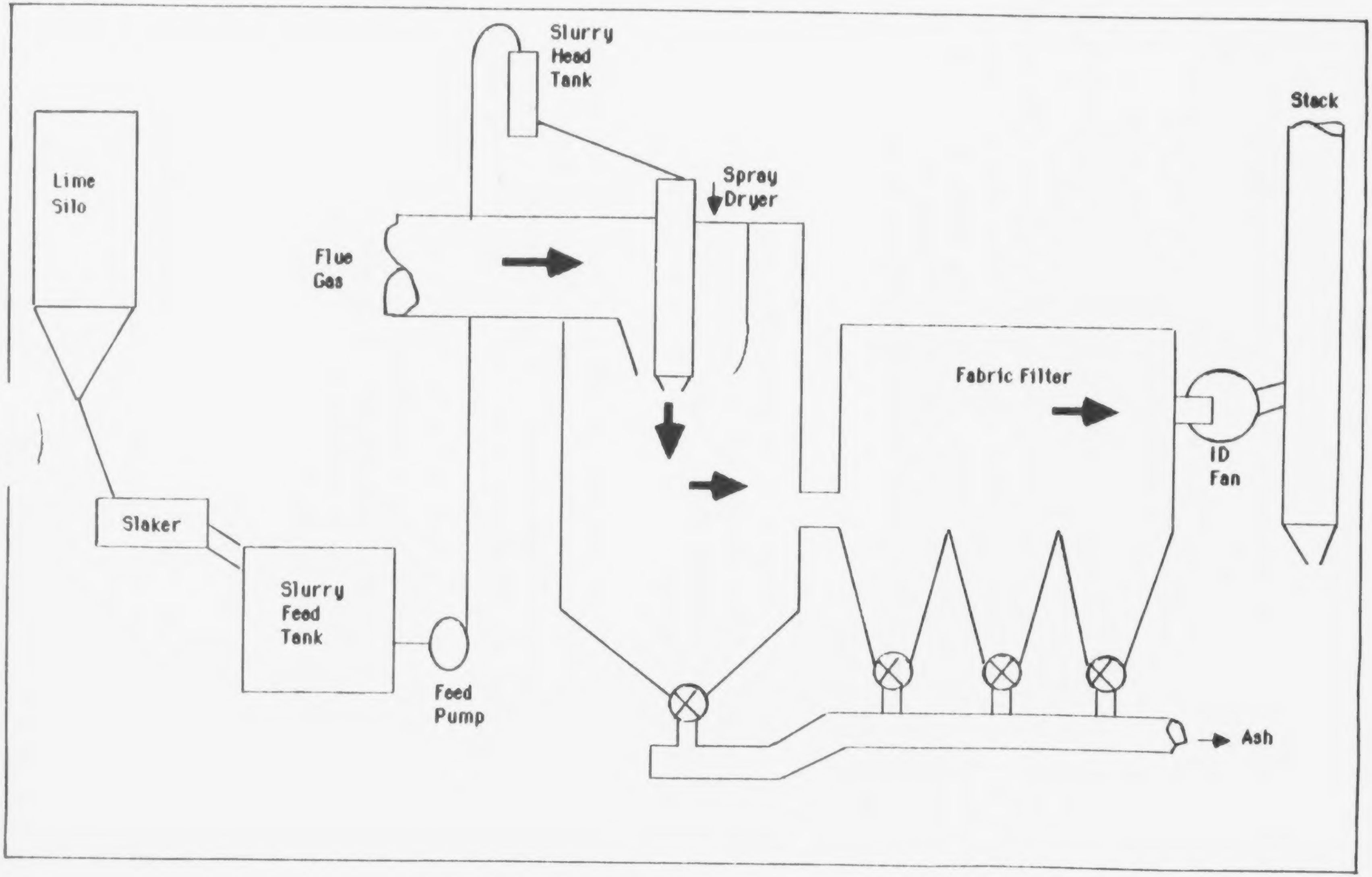

Slurry Head Tank
Stack
Lime Silo
Spray Dryer
Flue Gas
Fabric Filter
ID Fan
Slaker
Slurry Feed Tank
Feed Pump
Ash

Figure 4-7. Dry Scrubber Fabric Filter System.

before gases are allowed to enter the wet ESP. The venturi can perform this function, which will optimize the performance of the wet ESP. To conserve electricity, the venturi can be adjusted to maintain the minimum pressure drop and function as a low-energy, low-pressure venturi.

The existing configuration for a typical fluid-bed furnace (Figure 4-4) is similar to the multiple-hearth furnace in that the venturi and impingement-plate aftercooler immediately follow the incinerator. (The hot or cold wind box is part of the fluid-bed incineration system, providing return air for combustion.) The fan, however, is located in a different position; therefore air is forced through the venturi rather than being pulled from the stack side of the aftercooler (which occurs with a multiple-hearth configuration).

The retrofit strategy for installing a fabric filter on a fluid-bed furnace is depicted in Figure 4-5. The fabric filter requires a quench chamber for cooling (as is the case with multiple-hearth furnaces), thus the venturi/impingement apparatus must be removed. The fabric filter equipment follows the cooling chamber.

Figure 4-6 illustrates the retrofit of the fluid-bed incinerator with a wet ESP system. The wet ESP is added after the existing scrubber/cooler system. With the fluid-bed configuration, the gases are heavily laden with ash (as opposed to the multiple-hearth furnace, where most of the ash remains as a dry solid and is collected from the bottom hearth). The venturi is critical since it removes a large portion of the ash from the gases before they enter the wet ESP. Ash removal is necessary for efficient operation of the ESP and for avoiding the use of the existing ash handling system. With the venturi in place, most of the coarse particles will continue to be collected in a thick ash slurry that is further thickened to a sludge for disposal. The finer particulates, collected by the ESP in a dilute slurry, can be returned to the headworks of the plant.

The dry scrubber and fabric filter require a different configuration, depicted in Figure 4-7. The lime is fed through a slaker and a series of slurry tanks to the spray dryer that injects the fine lime particles into the combustion gases coming from the incinerator. The gases are then directed through the fabric filter before being pulled out of the stack by the induced draft fan. This schematic would apply to all three types of incinerators.

Removal Efficiencies of Pollution Control Devices

Studies of the pollution control efficiencies available using the three pollution control devices under consideration were investigated. EPA conducted pilot plant tests to determine the potential removal efficiencies associated with dry ESPs and fabric filters.[3] The test results are shown in Table 4-8. The tests concluded that dry electrostatic precipitators and fabric filters can achieve overall particulate removal efficiencies 10 to 20 percent higher than a combination of a venturi scrubber with an impingement aftercooler.

Wet ESPs are reputed to achieve removal efficiencies equal to or greater than dry ESPs or fabric filters; however, there are no test data on sewage sludge incinerators to support these claims. Removal efficiencies are enhanced with a wet ESP if the existing scrubber is kept within the system. Although collection efficiencies of the two systems together will not be cumulative, 99 percent removal of trace elements is said to be achieved. Wet ESPs will also remove some volatile organic compounds that condense at the equipment operating temperature.[4]

Dry scrubbing systems coupled with fabric filters have been used on solid waste and hazardous waste incinerators. A report from the National Incinerator Testing and Evaluation Program of Canada[5] shows results of performance tests on solid waste incinerators with dry scrubbers and fabric filters that indicate greater than 99 percent removal of cadmium, lead, chromium, nickel, and arsenic and over 97 percent removal of mercury. Organics such as chlorobenzenes, chlorophenols and PCBs are shown to be reduced by 98 percent to over 99 percent. No test data on the performance of these systems in sewage sludge incinerators are available.

TABLE 4-8

SUMMARY OF TRACE METALS REMOVAL EFFICIENCIES (PERCENT)

ELEMENT	VENTURI SCRUBBER WITH IMPINGEMENT PLATE AFTERCOOLER	ELECTROSTATIC PRECIPITATOR	FABRIC FILTERS
Chromium	<85	86-95	85-95
Cadmium	64-85	>95	95-99
Arsenic	86-95	>95	95-99
Lead	65-85	>95	>99

Source: R.C. Adams, G. Bockol, J.A. Maddox, and E.V. Robb, Radian Corporation, Particulate Removal Evaluation of an Electrostatic Precipitator Dust Removal System Installed on a Multiple Hearth Incinerator Burning Sewage Sludge, September 1985. R.C. Adams, L.E. Keller, and E.V. Robb, Radian Corporation, Particulate Removal Capability of a Baghouse Filter on Exhaust of a Multiple Hearth Furnace Burning Sewage Sludge, September 1986.

To determine what pollution control equipment might be used on sewage sludge incinerators, the pollution control efficiencies that must be achieved to meet the requirements of the regulation (based on the concentrations of lead in the three sludge profiles) must be determined. This efficiency can be thought of as the "required" lead removal efficiency. The regulation provides an equation that relates pollutant concentration to control efficiency. The required pollution control efficiency is that percent removal which allows the actual lead concentration in the sludge to equal the maximum allowable lead concentration. This required efficiency was calculated for all model facilities using the estimated lead concentrations in each of the three sludge profiles. The 25th percentile removal efficiency for lead is about 77 percent.[6] The incinerators that fail to meet the lead criterion are estimated to require lead removal efficiencies primarily ranging between 77 percent and 99 percent. A few facilities are estimated to require lead removal efficiencies greater than 99 percent.

The test results shown in Table 4-8 indicate that the removal efficiencies needed to meet the lead criterion may be theoretically achievable for most sewage sludge incinerators using wet electrostatic precipitators or fabric filters. Since at this time no data are available to determine whether he required control efficiencies can be met with a particular item of pollution control equipment, this factor was not used to determine a choice of control equipment in deriving a point estimate. Instead, a range of costs was determined based on the assumption that either fabric filters, wet ESPs, or dry scrubbers with fabric filters are each retrofitted to all incinerators that fail the lead criterion. The costs of these retrofit scenarios are discussed below. A point estimate is then derived assuming that all POTWs choose only wet ESPs to control lead emissions.

Costs of Control Equipment Retrofits

This section presents aggregate costs of the three retrofit technology options, as well as a point estimate of retrofit costs assuming all POTWs choose wet ESPs. As noted above, a total of 96 POTWs (174 incinerators) are estimated to fail the lead criterion at Tier 2 and are assumed to require pollution control equipment retrofits. All ocean ban POTWs are assumed to have wet ESPs or fabric filters in place and are thus estimated to incur no additional pollution control costs.

The unit costs of each retrofit were developed using engineering estimates.[7] The numbers of units in each size category for each type of incinerator were estimated using equipment supplier lists and field records[3]

The costs are presented in terms of total annual costs for all incinerator units, which include: annualized capital costs; installation and engineering expenses; and yearly operation and maintenance costs. In estimating annual costs, all incinerators were assumed to operate at 70 percent capacity utilization. This assumption may not be appropriate for some plants. Many plants have parallel units that operate reciprocally during routine maintenance or at other times. Other plants operate their incinerators only a few days each week. In the absence of data on capacity utilization at each sewage sludge incinerator, 70 percent was used to represent average incinerator operations.

The annual costs are first presented assuming that all incinerators retrofit only one type of pollution control device, either fabric filters, wet ESPs, or dry scrubbers with fabric filters. This presentation allows a range of retrofit costs to be calculated. Following these estimates, total costs are estimated assuming all POTWs select wet ESPs for control of lead emissions.

The total costs, assuming all units that fail to meet the metals criteria choose the wet ESP option, are $20.8 million (see Table 4-9). The costs associated with the addition of fabric filters are $18.4 million (see Table 4-10). The dry scrubber/fabric filter option is the most expensive. Retrofitting this device on all units that fail to meet the criteria is estimated to cost $161.3 million (see Table 4-11). These costs show the potential range of pollution control costs that might be incurred under Option 1: $18.4 million to $161.3 million.

TABLE 4-9

COST OF UPGRADED POLLUTION CONTROL SYSTEMS
TOTAL ANNUAL COST OF ELECTROSTATIC
PRECIPITATORS UNDER OPTION 1
($ 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			ELECTRIC FURNACES			
SIZE	NO. UNITS	ANNUAL UNIT COST WET ESP	TOTAL ANNUAL COST	NO. UNITS	ANNUAL UNIT COST WET ESP	TOTAL ANNUAL COST	NO. UNITS	ANNUAL UNIT COST WET ESP	TOTAL ANNUAL COST	GRAND TOTAL ANNUAL COST WET ESP
0.5 MGD	0	$ 23,013	$ 0	0	$17,954	$ 0	0	$16,364	$ 0	$ 0
2 MGD	28	53,905	1,509,339	12	37,155	445,854	2	26,483	52,966	2,008,159
14 MGD	74	115,343	8,535,362	4	55,354	221,415	0	48,600	0	8,756,781
128 MGD	60	166,681	10,000,851	0	95,118	0	0	NE	0	10,000,851
Total	162		$20,045,557	16		$ 667,269	2		$ 52,966	$20,765,791

NE = not estimated.

Source: ERG estimates.

TABLE 4-10

COST OF UPGRADED POLLUTION CONTROL SYSTEMS
TOTAL ANNUAL COST OF FABRIC FILTERS
UNDER OPTION 1
($ 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			ELECTRIC FURNACES			
SIZE	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL ANNUAL COST	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL ANNUAL COST	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL ANNUAL COST	GRAND TOTAL ANNUAL COSTS FABRIC FILTERS
0.5 MGD	0	$ 17,139	$ 0	0	$ 28,767	$ 0	0	$ 10,611	$ 0	$ 0
2 MGD	28	47,826	1,339,128	12	473,540	568,247	2	24,893	49,786	1,957,161
14 MGD	74	101,239	7,491,685	4	195,621	260,828	0	62,390	0	7,752,513
128 MGD	60	145,311	8,718,638	0	95,118	0	0	45,945	0	8,718,638
Total	162		$17,549,451	16		$ 829,075	2		$ 49,786	$18,428,312

Source: ERG estimates.

TABLE 4-11

COST OF UPGRADED POLLUTION CONTROL SYSTEMS TOTAL ANNUAL COST OF DRY SCRUBBERS UNDER OPTION 1

($ MILLIONS 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			
SIZE	NO. UNIT[a]	ANNUAL UNIT COST DRY SCRUBBERS	TOTAL ANNUAL COST	NO. UNITS	ANNUAL UNIT COST DRY SCRUBBERS	TOTAL ANNUAL COST	GRAND TOTAL ANNUAL COST DRY SCRUBBERS
0.5 MGD	0	$0.14	$ 0.00	0	$0.13	$ 0.00	$ 0.00
2 MGD	30	0.33	9.76	12	0.28	3.40	13.15
14 MGD	74	0.79	58.22	4	0.45	1.80	60.02
128 MGD	60	1.47	88.12	0	0.71	0	88.12
Total	164		$156.09	16		$ 5.20	$161.29

[a] Includes two electric furnaces (costs for these furnaces are assumed similar to those for multiple-hearth furnaces, since no cost estimates are available for retrofitting dry scrubbers to electric furnaces).

Source: ERG estimates.

For the purposes of deriving a point estimate, wet ESPs have been assumed to be installed on all incinerators that fail to meet the lead criterion. It is further assumed that installation of wet ESPs will allow all incinerators to meet the lead emission criterion. For many incinerators, installing a wet ESP is often the most practical option for several reasons. First, since the venturi/impingement systems can be left intact with the wet ESP, gas flows entering the wet ESP will be reduced (the gas will be at a lower temperature; thus, it will have less volume). Smaller equipment than that needed for a comparable fabric filter system will then be necessary. Second, in the case of a wet ESP, equipment dismantling and removal costs are avoided if the existing scrubber remains. Ash slurry from the wet ESP can be returned to the headworks of the plant for treatment. Fabric filters require separate ash handling equipment and disposal. As noted above, the total retrofit costs associated with wet ESPs installed on all incinerators that fail the lead criterion are $20.8 million.

Summary of Compliance Costs

Table 4-12 presents the aggregate compliance costs for sewage sludge incinerators. The aggregate costs include sludge testing costs, performance testing costs, dispersion modeling costs, and costs to retrofit wet ESPs for pollution control. These costs total $22.8 million. Note that performance testing and dispersion modeling costs are one-time costs. Thus the $22.8 million figure represents a first-year cost of compliance. The compliance costs that will be incurred by POTWs in years subsequent to the first are $20.9 million annually.

Incremental compliance costs can be averaged over the households in the service territories of the POTWs affected by the proposed regulation. POTW operating costs are allocated over all customers - industrial, commercial, and residential. In the absence of data necessary to provide averages over all customers, however, it is useful to average total incremental costs over the residential population only. The 1984 Needs Survey provides data on the residential population served by each POTW. The total residential population

TABLE 4-12

SUMMARY OF COMPLIANCE COSTS FOR INCINERATION UNDER OPTION 1

($1987)

SIZE	SLUDGE TESTING	PERFORMANCE TESTING AND DISPERSION MODELING	POLLUTION CONTROL COSTS	TOTAL COST[a]
0.1 MGD	$ 0	$ 0	$ 0	$ 0
0.5 MGD	525	25,662	0	26,187
2 MGD	31,080	645,057	2,008,159	2,684,296
14 MGD	103,320	841,036	8,756,781	9,701,137
128 MGD	41,580	393,127	10,000,851	10,435,558
Total	$176,505	$1,904,882	$20,765,791	$22,847,178

[a] This total is for first-year costs. Recurring annual costs will not include costs of incinerator performance testing and dispersion modeling and will total $20,942,296.

Source: ERG estimates.

served by POTWs currently using incineration is 24.9 million. Assuming three persons per household,[9] the incremental first-year per-household charges are $2.75 since all but $26,670 of incremental costs are attributable to POTWs with existing incinerators. In subsequent years, the incremental per-household cost will be $2.52 annually. The ocean ban POTWs serve 9.9 million residents. The incremental costs of complying with Option 1 on a per-household basis for these POTWs are estimated to be less than $0.01 annually. As noted, actual per-household costs would be somewhat lower for both groups of POTWs when incremental costs are apportioned over all customers.

4.1.2 Costs and Impacts of Regulatory Option 1 on POTWs Practicing Monofilling, Land Application, and Distribution and Marketing

All POTWs practicing monofilling, land application, and distribution and marketing are currently estimated to be in compliance with the TCLP criteria in Option 1. Additionally, all other Option 1 requirements for these disposal methods are currently mandated by existing regulations. Thus, the relevant sewage sludge disposal costs for these three disposal methods are baseline costs, which were developed in Section Three. No incremental costs for disposal are derived.

Sludge testing for pollutants is, however, required under Option 1, thus testing costs will be incurred by these POTWs. The frequency of testing varies depending on the size of the POTW. Facilities processing less than 1 MGD wastewater are required to test annually; those processing 1 to 10 MGD must test quarterly; and those processing more than 10 MGD must test monthly. Metals must be analyzed at an estimated $15 or $18 per metal for noncomposted and composted sludge, respectively. Analysis for organics costs $698 or $823, depending on whether the sludge is composted (the higher cost is for composted sludge). These costs are based on average charges to obtain sludge testing services at independent testing laboratories. Total testing costs for POTWs practicing these three disposal methods are $4.8 million, as shown in Table 4-13.

TABLE 4-13

ANNUAL SLUDGE TESTING COSTS FOR POTWS PRACTICING MONOFILLING LAND APPLICATION, AND DISTRIBUTION AND MARKETING UNDER OPTION 1
($1987)

SIZE	NO. OF POTWS	COST OF TESTING PER POTW/YR	TOTAL TESTING COST
		MONOFILLS (4 METALS)[a]	
0.1 MGD	5	$ 758	$ 3,790
0.5 MGD	14	758	10,612
2 MGD	19	3,032	57,608
14 MGD	10	9,096	90,960
128 MGD	1	9,096	9,096
TOTAL	49		$172,066
		LAND APPLICATION (6 METALS)[a]	
0.1 MGD	1,071	$ 788	$ 843,948
0.5 MGD	889	788	700,532
2 MGD	591	3,152	1,862,832
14 MGD	65	9,456	614,640
128 MGD	7	9,456	66,192
TOTAL	2,623		$4,088,144
		DISTRIBUTION AND MARKETING (6 METALS)[a]	
0.1 MGD	5	$ 931	$ 4,655
0.5 MGD	27	931	25,137
2 MGD	45	3,724	167,580
14 MGD	16	11,172	178,752
128 MGD	13	11,172	145,236
TOTAL	106		$521,360
GRAND TOTAL	2,778		$4,781,570

Source: ERG estimates.

[a] Varying numbers of metals have criteria specified under each disposal option. The metals requiring testing under Option 1 are strictly those for which TCLP criteria have been specified.

Based on data provided by the 1984 Needs Survey, approximately 1.8 million residents are served by POTWs using sludge monofills; 29.2 million residents are served by POTWs using land application; and 16.3 million residents are served by POTWs using distribution and marketing. Assuming three residents per household, total annual incremental costs associated with Option 1 requirements for these three disposal methods are $0.29 per household for monofills, $0.42 per household for land application, and $0.10 per household for distribution and marketing. Actual per-household costs would be somewhat lower because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

4.1.3 Summary of Option 1 Compliance Costs

Table 4-14 presents the summary of incremental costs associated with Option 1. A total incremental cost of $27.6 million is associated with this option, based on the choice of wet ESPs as pollution control equipment for sewage sludge incinerators. The highest compliance costs are associated with incineration at $22.8 million. Land application is associated with compliance costs of $4.1 million, monofills with costs of $172,066, and distribution and marketing with costs of $521,360. Note that the $27.6 million total for Option 1 compliance costs represents a first-year cost, since incinerator emissions testing and dispersion modeling costs are one-time costs. The compliance costs incurred by POTWs under Option 1 in subsequent years total $25.7 million annually.

4.2 Costs and Impacts of Regulatory Option 2

Option 2 sets limits to protect human health and the environment from the most contaminated sewage sludges. In general, the maximum pollutant concentration criteria are set at the 98th percentile sludge concentrations defined in Section Three. Therefore, by definition, all POTWs associated with the 98th percentile sludge profile fail to meet the Option 2 regulatory pollutant concentration limits.

TABLE 4-14

TOTAL ANNUAL INCREMENTAL COSTS ASSOCIATED WITH OPTION 1
($1987)

SIZE	INCINERA-ERATION	MONOFILLS	LAND APPLICATION	DISTRIBUTION AND MARKETING	TOTAL COMPLIANCE COSTS[a]
0.1 MGD	$ 0	$ 3,790	$ 843,948	$ 4,655	$ 852,393
0.5 MGD	26,187	10,612	700,532	25,137	762,468
2 MGD	2,684,296	57,608	1,862,832	167,580	4,772,316
14 MGD	9,701,137	90,960	614,640	178,752	10,585,489
128 MGD	10,435,558	9,096	66,192	145,236	10,656,082
Total	$22,847,178	$172,066	$4,088,144	$521,360	$27,628,748

[a] This total is for first-year costs. Recurring annual costs will not include costs of incinerator performance testing and dispersion modeling and will total $25,723,866.

Source: ERG estimates.

Additional criteria identical to those proposed for Option 1 also apply; all but the lead concentration criterion for incinerated sludges are required under current regulations. Thus, the same POTWs failing to meet Option 1 criteria for incineration will fail under Option 2. An additional group of incinerators burning 98th percentile sludges will also fail since the criteria are based on 98th percentile sludge concentrations. (One model facility incinerating 98th percentile sludges passes the lead criterion under Option 1 at Tier 2; no ocean ban POTWs generate 98th percentile sludge). Furthermore, POTWs generating 98th percentile sludge will fail to meet other Option 2 criteria when monofilled, land applied, or distributed and marketed. Thus, Option 2 is more stringent than Option 1, and incremental costs greater than those for Option 1 will be incurred if POTWs are required to comply with this regulatory option.

All POTWs (other than those using incineration) assigned to the typical and 90th percentile sludge profiles will meet the proposed Option 2 criteria and will be subject to the existing regulations. The POTWs that meet the Option 2 criteria will, however, be subject to incremental pollutant testing requirements (as were discussed in Option 1) and certain additional management practices. These management practices include disease vector controls, methane gas monitoring, and runon/runoff control systems for certain disposal methods. Recordkeeping and reporting are not required, however, under this option. Pathogen testing and vector reduction parameter testing are also not required.

The sections below discuss the costs and impacts of Option 2 on POTWs practicing each of the four regulated disposal methods. Note that surface impoundments are not covered by Option 2 regulatory requirements.

4.2.1 Costs and Impacts of Regulatory Option 2 Concerning Sewage Sludge Incinerators

The same lead criterion is proposed for Option 2 as for Option 1. Thus, the same number of POTWs and incinerators that burn typical and 90th percentile sludges are out of compliance with the lead criterion under Option

2 at Tier 2 as under Option 1. Additionally, all incinerators burning 98th percentile sludges are projected to fail at Tier 1 based on the definition of the 98th percentile criteria. One model facility burning 98th percentile sludges passed under Option 1; this model, however, represents no actual facilities burning 98th percentile sludges. Thus, costs for pollution control equipment incremental to those for Option 1 are incurred under Option 2.

At Tier 1, 122 POTWs with 219 existing incinerators fail to meet the lead criterion under Option 2. This is the same number of POTWs and incinerators that fail under Option 1, Tier 1. Thus costs associated with demonstrating compliance using performance testing and air dispersion modeling at Tier 2 remain the same for Option 2 as under Option 1 ($1.9 million - see Table 4-14). Note that the ocean ban POTWs are assumed to incur these costs as part of their permitting requirements, not as a result of any of the sewage sludge regulatory option requirements. All POTWs (including the 25 ocean ban POTWs) will be required to test their sludge, as was required under Option 1. Thus testing costs are the same for Option 2 as for Option 1 ($176,505).

Since all costs remain the same under Option 2 as under Option 1, the total incremental costs of the incinerator regulations under Option 2 are $22.8 million (see Table 4-15). Note that performance testing and air dispersion modeling are one-time costs. Thus the $20.9 million figure represents a first-year cost of compliance. Annual compliance costs for subsequent years total $20.2 million.

Approximately 24.9 million residents are served by POTWs currently using incineration. Assuming three residents per household, total annual incremental costs associated with Option 2 incinerator requirements for existing incinerators are $2.75 per household in the first year since all but $26,670 of incremental costs are attributable to POTWs with existing incinerators. In subsequent years, incremental per-household costs total $2.52 per year. The ocean ban POTWs serve 9.9 million residents. The incremental costs of complying with Option 2 on a per-household basis are estimated to be less than $0.01 annually. Actual costs per household would be somewhat lower for both groups of POTWs because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

TABLE 4-15

SUMMARY OF AGGREGATE COMPLIANCE COSTS FOR INCINERATION UNDER OPTION 2
($1987)

SIZE	SLUDGE TESTING COSTS	PERFORMANCE TESTING AND DISPERSION MODELING COSTS	POLLUTION CONTROL COSTS	TOTAL COSTS[a]
0.1 MGD	$ 0	$ 0	$ 0	$ 0
0.5 MGD	525	25,662	0	26,187
2 MGD	31,080	645,057	2,008,159	2,684,296
14 MGD	103,320	841,036	8,756,781	9,701,137
128 MGD	41,580	393,127	10,000,851	10,435,558
Total	$176,505	$1,904,882	$20,765,791	$22,847,178

[a] This total is for first-year costs. Recurring annual costs will not include costs of performance testing and dispersion modeling and will total $20,942,296.

Source: ERG estimates.

4.2.2 Costs and Impacts of Regulatory Option 2 Governing the Disposal of Sewage Sludge in Landfills

This section summarizes the costs and impacts of regulatory Option 2 on the disposal of sewage sludge in monofills. Sewage sludge is disposed of in monofills (landfills that accept only sewage sludge) or in codisposal landfills. Codisposal of sewage sludge is not covered as one of the disposal methods under any of the regulatory options; rather, it will be covered by proposed regulations in 40 CFR Part 258. Only the costs and impacts associated with monofills will be addressed by this RIA.

4.2.2.1 Sizes and Number of POTWs Affected Under Option 2 Requirements for Monofill Disposal

The 42 POTWs corresponding to the typical and 90th percentile sludge profiles are projected to be in compliance with Option 2 pollutant concentrations. Only the POTWs estimated to produce 98th percentile sludges fail to meet the Option 2 maximum pollutant concentrations. Thus, seven POTWs are affected by this option: two POTWs in the 0.5-MGD size class, and five POTWs in the 2-MGD size class.

4.2.2.2 Compliance Costs

Costs of Shifts in Disposal Practice

The seven POTWs generating 98th percentile sludge fail to meet Option 2 criteria. They must, therefore, shift to an acceptable alternative method of disposal, but alternative disposal methods are limited. The pollutant concentrations for this sludge profile fail not only under monofill criteria, but also fail under criteria for land application and distribution and marketing. Ocean disposal has been banned, so it is also unavailable as an alternative disposal method.

Only three logical choices remain: (1) codisposal, which allows all nonhazardous waste types to be disposed subject to technical and management practice requirements; (2) incineration, which allows for pollution control equipment to be used to meet criteria; and (3) composting the sludge and then monofilling it.

The option of composting the sludge with subsequent monofilling is available because when sludge is composted, its pollutant concentrations are reduced below the 98th percentile limits. Composted sludge is mixed with bulking agents such as wood chips before being distributed. Thus a dilution factor is incorporated. The dilution is based on an assumed mix of sludge with woodchips in a 2.51:1 ratio by volume. On a mass basis, this translates to 0.87 tons of woodchips to 1 ton of sludge. The final concentration of contaminants in compost is calculated using the following equation:[10]

$$\frac{0.22\ (\text{ppm of sludge, dry weight})/0.38}{1 + 0.33\ \left(\frac{0.87\ \text{tons woodchips}}{\text{ton sludge}}\right)} = \text{ppm of compost, dry weight}$$

This equation produces an estimate of a 44 percent dilution factor for contaminants in sludge (e.g., 1 ppm lead will become 0.44 ppm lead in composted sludge).

Of the other two options, codisposal may not be available as an option for many POTWs. As discussed in Section Three, municipal landfill siting problems, capacity declines, and landfill closures have created critical shortages of landfill space in many areas. It is thus assumed that the smallest facilities (the 0.1-MGD and 0.5-MGD facilities) are more likely to be able to codispose sewage sludge than larger facilities since the volume of waste produced annually by small facilities would probably have a minimal impact on current landfill capacity. Thus, the 0.5-MGD POTWs estimated to fail Option 2 criteria are assumed to shift to codisposal. In contrast, the volumes of waste generated by larger facilities would probably have a significant impact on existing landfill capacity problems. The disposal options available to these larger facilities are estimated to be limited to composting with monofilling, or incineration.

The moderate-sized (2-MGD and 14-MGD) POTWs are assumed to use composting with subsequent monofilling since this disposal method is less expensive than incineration for facilities in these size classes (see Section Three for a discussion of baseline costs of disposal). Thus, the 2-MGD POTWs estimated to fail Option 2 criteria are assumed to compost their sludge before monofilling.

The costs for codisposal, composting, and monofilling were developed in Section Three. Total costs per DMT for codisposal by 0.5-MGD POTWs are $340. The 2-MGD POTWs are faced with a $571/DMT cost for composting and monofilling.

Table 4-16 presents compliance cost estimates associated with POTWs that must shift from monofilling to codisposal and to composting and monofilling. The total estimated incremental cost of compliance is $749,104.

Sludge Testing Costs

Sludge testing is required for all POTWs except those estimated to shift to codisposal (which is not covered under any of the regulatory options). Requirements for initial testing to determine whether sludge can be monofilled are assumed to be fulfilled when sludge is tested to determine whether it is hazardous. The costs of initial testing are thus incurred as part of RCRA requirements. Only those POTWs practicing disposal methods covered under the proposed regulatory option incur the costs of subsequent testing. The numbers of tests required annually vary depending on the amount of wastewater processed each day by the facility, as discussed for this disposal method under Option 1. All sludge testing is assumed to be incremental. Existing Subtitle D regulations for the states do not specify sludge testing parameters for monofilled sludge. Incremental testing costs for all POTWs include the tests needed to meet the required frequency and number of parameters. Testing costs per sample are assumed to be $15 or $18 per metal for six metals and $698 or $823 for all organics for noncomposted and composted sludges, respectively, based on reported costs of sludge analysis from independent testing laboratories. Table 4-17 presents the total sludge testing costs for monofilled sludges of $180,160.

TABLE 4-16

TOTAL ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL METHODS FOR POTWS PRACTICING MONOFILLING UNDER OPTION 2

($1987)

SIZE	NUMBER OF POTWS	BASE-LINE COST (DMT)[a]	ALTER-NATIVE DISPOSAL OPTION	COST OF ALTER-NATIVE/ DMT	INCRE-MENTAL COST/DMT	TOTAL INCREMENTAL COST[b]
0.1 MGD	0	$301	Codisposal	$340	$39	$ 0
0.5 MGD	2	183	Codisposal	290	107	23,754
2 MGD	5	245	Composting and mono-filling	571	326	725,350
14 MGD	0	83	Composting and mono-filling	246	163	0
128 MGD	0	55	Incineration	156[c]	101	0
Total	7					$749,104

[a] See Table 3-31 in Section Three.

[b] Based on quantity of sludge generated per year of 22 DMT for 0.1 MGD POTWs, 111 DMT for 0.5 MGD POTWs, 445 DMT for 2 MGD POTWs, 3,116 DMT for 14 POTWs, and 28,478 DMT for 128 MGD POTWs.

[c] Includes cost for wet ESPs on some incinerators to meet Option 2 pollution control requirements.

Source: ERG estimates.

TABLE 4-17

ANNUAL SLUDGE TESTING COSTS FOR POTWS PRACTICING MONOFILLING UNDER OPTION 2
($1987)

SIZE	NO. OF POTWs	FREQUENCY	TESTING COST	TOTAL COST
0.1 MGD	5	1/yr	$ 788	$ 3,940
0.5 MGD	12	1/yr	788	9,456
2 MGD	14/5[a]	4/yr	3,152/3,724[b]	62,748
14 MGD	10	1/mo	9,456	94,560
128 MGD	1	1/mo	9,456	9,456
Total	47[c]			$180,160

[a] Number appearing after slash is number of POTWs shifting to composting.

[b] Cost appearing after slash is cost for testing composted sludge.

[c] Totals exclude two POTWs that are estimated to shift to codisposal.

Source: ERG estimates.

Management Practices

Management practices required under Option 2 include disease vector controls, methane gas monitoring and runon/runoff control systems. Part 257 and proposed Part 258 regulations require these or equivalent types of management practices, although Part 258 does not cover monofills unless the POTW accepts septage. In addition, many of these management practices are current practices. No incremental costs have been estimated for Option 2 management practice requirements for monofill.

Liners and Leachate Collection Systems

One alternative to shifting disposal practices is modifying the current practice so that pollutant releases are controlled. For example, adding liners and leachate collection systems to monofills could reduce pollutant releases to groundwater. This alternative is not considered to be a means of compliance because the quality of the sludge is not changed. However, the costs of liners and leachate collection systems are discussed in this section and compared to the costs of shifts in disposal practice. This comparison is meant to illustrate the range of options that POTWs might consider.

The annual costs of installing liners and leachate collection systems was developed for the five model facility sizes. These costs were estimated using a computer model developed by EPA. The modeled leachate collection system is composed of a leachate main and branch system. The leachate is transported through this system by gravity and pumps and is then routed to a temporary storage well prior to treatment. The leachate system rests on a 0.3-meter layer of sand and a 30-millimeter synthetic liner. These liners are the most expensive elements of the leachate system. A filter fabric is placed above the sand layer to minimize the chance that the leachate system will become clogged by large particles. A support fabric is placed below the synthetic liner to protect the liner from tears.

The first facility size is designed to accept approximately 100 wet metric tons (WMT) of sludge per year, the waste of a 0.1-MGD POTW. Leachate treatment is assumed to occur offsite at this size facility, as it is for all but the two largest size facilities. The second size facility is designed to accept approximately 500 wet metric tons of sludge per year, which corresponds to the 0.5-MGD POTW. The third facility accepts 2,000 MT per year, corresponding to the 2-MGD plant. A 15,000-MT facility was also modeled, corresponding to a 14-MGD POTW. Leachate treatment systems are installed onsite in the facilities in this category. Finally, a 130,000-MT facility was modeled for POTWs in the 128-MGD class. Annual leachate treatment costs were based on $0.11/gallon treatment cost for the two largest facility sizes and $0.81/gal for the smaller POTWs, which are assumed to use offsite leachate treatment facilities.

As Table 4-18 shows, the annual incremental costs for adding liners and leachate collection systems range from $45 to $488/DMT. For the facilities affected under Option 2 (0.5-MGD and 2-MGD facilities) adding liners and leachate collection systems is more expensive than using codisposal or composting with subsequent monofilling. Therefore, no POTWs projected to fail Option 2 requirements are likely to use liners and leachate collection to achieve compliance with Option 2 regulations, even if this alternative were available.

Summary of Total Compliance Costs

The total compliance costs for POTWs practicing monofilling are shown in Table 4-19. The costs associated with shifting to alternative disposal methods and sludge testing total $929,264. Note that in the affected size classes, it would be less expensive to shift to codisposal or to composting and monofilling than to install liners and leachate collection systems.

Approximately 1.8 million residents are served by POTWs using sludge monofills. Assuming three residents per household, total annual incremental costs associated with Option 2 monofill requirements are $1.56 per household.

TABLE 4-18

ANNUAL COSTS OF LINER AND LEACHATE COLLECTION SYSTEMS FOR SLUDGE MONOFILLS
($1987)

	SIZE CLASS				
	1	2	3	4	5
Landfill Size (MT/Year)	100	500	2,000	15,000	130,000
Capital Costs Per Facility					
Filter fabric	$ 1,823	$ 5,473	$ 12,583	$ 58,001	$ 269,795
Sand liner	2,814	8,993	22,088	104,824	498,588
Synthetic liner	5,073	15,847	37,114	174,358	818,329
Support fabric	1,660	5,184	12,141	57,039	267,706
Leachate branch	165	1,364	2,794	17,060	87,582
Leachate main	238	644	986	2,665	6,150
Wet well and sump	12,960	12,960	12,960	12,960	12,960
Leachate treatment system	0	0	0	63,504	116,748
Subtotal - Capital	$24,733	$50,465	$100,666	$490,411	$2,077,858
Annual Costs Per Facility					
Annual treatment cost	$ 6,912	$34,560	$131,004	$119,664	$ 950,724
Total Annual Costs Per Facility					
Capital costs	$24,733	$50,465	$100,666	$490,411	$2,077,858
Annualized capital costs	3,820	7,794	15,548	75,745	320,927
Annual treatment costs	6,912	34,560	131,004	119,664	950,724
Total Annual Costs	$10,732	$42,354	$146,552	$195,409	$1,271,651
Total Incremental Cost per DMT[a]	$ 488	$ 382	$ 329	$ 63	$ 45

[a] These costs would be incurred in addition to baseline costs of monofilling.

Source: ERG calculations, 1988, and Facilities Design Tool Cost Model, Office of Solid Waste, U.S. EPA, March 1984, prepared by Pope-Reid Associates, Inc.

TABLE 4-19

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWs PRACTICING MONOFILLING UNDER OPTION 2

($1987)

SIZE	TESTING COST	COST OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICE	TOTAL
0.1 MGD	$ 3,940	$ 0	$ 3,940
0.5 MGD	9,456	23,754	33,210
2 MGD	62,748	725,350	788,098
14 MGD	94,560	0	94,560
128 MGD	9,456	0	9,456
Total	$180,160	$749,104	$929,264

Source: ERG estimates.

2036S

Actual costs per household would be somewhat lower because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

4.2.3 Costs and Impacts of Regulatory Option 2 Concerning the Land Application of Sewage Sludge

Land application of sewage sludge is defined as the application of liquid, dewatered, dried, or composted sewage sludge to either agricultural or nonagricultural land. Sludge disposal defined as distribution and marketing is also a form of land application, but this analysis distinguishes distribution and marketing by assuming all POTWs that compost their sludge practice distribution and marketing.

This section provides an overview of the impacts of Option 2 on the land application of sewage sludge and examines the associated compliance costs. It is assumed that all POTWs generating 98th percentile sludge will fail the Option 2 maximum pollutant level criteria for land application. All other POTWs are required to meet existing baseline regulations. Note that application rates are not relevant to these criteria because the criteria have been defined strictly on the basis of the 98th percentile sludge profile. The following sections present the sizes and numbers of affected POTWs and the incremental costs associated with the implementation of Option 2 for sludges that are land applied.

4.2.3.1 Sizes and Numbers of POTWs Affected by Option 2 Requirements for Land Application

All POTWs land applying 98th percentile sludge fail to meet Option 2 criteria, regardless of the end use of the sludge. It is, however, necessary to distinguish the different land application end uses since baseline costs differ among the different types of disposal methods. Based on a telephone survey conducted by EPA, the distribution of POTWs using various land application end uses was determined. (The results of this survey were presented in Table 3-17.) Table 4-20 presents the percentage distribution of

TABLE 4-20

DISTRIBUTION OF LAND APPLICATION END USES

END USE		PERCENTAGE OF ALL LAND-APPLIED SEWAGE SLUDGE
Dedicated Land		7%
Silviculture[a]		0%
Land Reclamation		3%
Agriculture		77%
Pasture	15%	
Feed Crops	56%	
Crops for Human Consumption	6%	
Other		13%
Total		100%

[a] Silviculture is currently an end use of sludge application used only on an experimental basis.

Source: ERG research.

agricultural land application, nonagricultural land application, and other end uses employed in analyzing the proposed land application regulations.

Table 4-21 summarizes the numbers of POTWs with 98th percentile sludge practicing the various types of land application methods by each class size. As the table shows, 42 POTWs producing 98th percentile sludges use agricultural land application, 7 use "other" end uses, and 5 use either dedicated disposal or reclamation for a total of 54 POTWs. The category "other" includes such end uses as golf courses, parks, nurseries, sod farms, and home gardens.

4.2.3.2 Compliance Costs

Costs of Shifts in Disposal Practice

The 98th percentile sludges that are land applied also fail criteria for monofilling and distribution and marketing, and ocean disposal is unavailable. Thus, as discussed in Section 4.2.2 on monofilling sewage sludge, the choices for POTWs that fail the 98th percentile criteria for Option 2 are limited to codisposal in municipal landfills, composting followed by land application, or incineration. Again, codisposal in municipal landfills appears feasible for the smaller (0.1-MGD and 0.5-MGD) facilities. The exception to this is the POTW in the 0.5-MGD size category that is currently estimated to be using land reclamation as a disposal method. Reclamation is very labor intensive, requiring extensive grading of marginal land. It is thus assumed that POTWs using land reclamation do not currently have less expensive disposal options, such as codisposal, available to them.

The POTW currently practicing reclamation, as well as larger POTWs using other land application methods, can, however, compost its sludge and then land apply it. Since the maximum pollutant concentrations for land application are defined by the pollutant concentration of the whole sludge, the pollutant concentrations of the same sludge when composted will be reduced due to dilution (see discussion in Section 4.2.2.2). Thus, 98th percentile sludges

TABLE 4-21

SIZE AND NUMBERS OF POTWS PRACTICING LAND APPLICATION THAT FAIL OPTION 2 CRITERIA

	NUMBER OF POTWS				
SIZE	AGRI-CULTURAL	OTHER	DEDICATED	RECLAMATION	TOTAL POTWS
0.1 MGD	4	1	0	0	5
0.5 MGD	16	3	1	1	21
2 MGD	19	3	2	1	25
14 MGD	3	0	0	0	3
128 MGD	0	0	0	0	0
Total	42	7	3	2	54

Source: ERG estimates.

2038S

currently being land applied can be composted and then land applied to meet the Option 2 criteria. The largest size POTWs (128 MGD) would, however, choose incineration for most land application end uses since this option is less expensive than composting plus land application for POTWs of this size. As noted in Section 4.2.2, POTWs in the three largest size classes are assumed to be unable to codispose sewage sludge because the large quantities of waste they generate would have significant impacts on municipal landfill capacity problems.

The costs of shifting to alternative disposal methods can be seen in Tables 4-22 through 4-25. The baseline costs for disposal practices were developed in Section Three. Baseline disposal costs for the "other" category are estimated to be negligible, since the POTWs are assumed neither to apply these sludges themselves nor to have the sludges applied by a contractor. Since baseline costs are negligible, the incremental costs for composting are less than those for incineration for the largest POTWs (128 MGD). The largest POTWs practicing "other" methods of sludge disposal are therefore estimated to compost their sludge rather than incinerate it. All the alternative disposal practices expected to be chosen can be seen in Tables 4-22 through 4-25.

POTWs practicing agricultural land application are expected to incur annual compliance costs of $4.5 million; those practicing dedicated disposal, $300,754; those practicing reclamation, $195,908; and those practicing "other" end use disposal, $539,260. Incremental disposal costs for all 54 POTWs estimated to shift disposal practices are $5.5 million.

Sludge Testing Costs

All POTWs, except those shifting to codisposal, are expected to incur sludge testing costs. Ten metals must be tested at $15 or $18 per metal; testing for all organics costs $698 or $823 for noncomposted and composted sludge, respectively. Testing must be performed annually at POTWs processing less than 1 MGD wastewater; quarterly at POTWs processing 1 to 10 MGD; and monthly at POTWs processing more than 10 MGD.

TABLE 4-22

TOTAL ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING LAND APPLICATION (AGRICULTURE) UNDER OPTION 2

($1987)

SIZE	NUMBER	BASE-LINE COST/ DMT	ALTER-NATIVE DISPOSAL METHOD	COST OF ALTER-NATIVE/ DMT	INCRE-MENTAL COST/DMT	TOTAL INCREMENTAL COST/DMT
0.1 MGD	4	$238	Codisposal	$340	$102	$ 8,976
0.5 MGD	16	179	Codisposal	290	111	197,136
2 MGD	19	176	Composting and land application	502	326	2,756,330
14 MGD	3	46	Composting and land application	209	163	1,523,724
128 MGD	0	42	Incineration	156[a]	114	0
Total	42					$4,486,166

[a] Includes cost of wet ESPs for some incinerators to meet Option 2 pollution control requirements.

Source: ERG estimates.

Note: DMT = Dry Metric Ton

2039S

TABLE 4-23

TOTAL ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING LAND APPLICATION (DEDICATED) UNDER OPTION 2

($1987)

SIZE	NUMBER	BASE-LINE COST	ALTER-NATIVE DISPOSAL OPTION	COST OF ALTER-NATIVE	INCRE-MENTAL COST/DMT	TOTAL INCREMENTAL COST
0.1 MGD	0	$279	Codisposal	$340	$61	$ 0
0.5 MGD	1	196	Codisposal	290	94	10,434
2 MGD	2	205	Composting and land application	531	326	290,140
14 MGD	0	57	Composting and land application	220	163	0
128 MGD	0	42	Incineration	156[a]	114	0
Total	3					$ 300,574

[a] Includes the cost of wet ESPs on some incinerators to meet Option 2 pollution control requirements.

Source: ERG estimates.

2040S

TABLE 4-24

TOTAL ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING LAND APPLICATION (RECLAMATION) UNDER OPTION 2

($1987)

SIZE	NUMBER	BASE-LINE COST	ALTER-NATIVE DISPOSAL OPTION	COST OF ALTER-NATIVE	INCRE-MENTAL COST/DMT	TOTAL INCREMENTAL COST
0.1 MGD	0	$636	Composting and land application	$1,449	$813	$ 0
0.5 MGD	1	356	Composting and land application	814	458	50,838
2 MGD	1	312	Composting and land application	638	326	145,070
14 MGD	0	173	Composting and land application	336	163	0
128 MGD	0	161	Incineration	156[a]	(5)	0
Total	2					$ 195,908

[a] Includes the cost of wet ESPs on some incinerators to meet Option 2 pollution control requirements.

Source: ERG estimates.

2041S

TABLE 4-25

TOTAL ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING LAND APPLICATION (OTHER) UNDER OPTION 2

($1987)

SIZE	NUMBER	ALTERNATIVE DISPOSAL METHOD	INCREMENTAL COST/DMT	TOTAL INCREMENTAL COST/DMT
0.1 MGD	1	Codisposal	$340	$ 7,480
0.5 MGD	3	Codisposal	290	96,570
2 MGD	3	Composting and land application	326	435,210
14 MGD	0	Composting and land application	163	0
128 MGD	0	Composting and land application	147	0
Total	7			$539,260

Source: ERG estimates.

As shown in Section Three, many states already require testing of a number of metals, and a few states require testing of a small portion of the applicable organics. The frequency with which POTWs are required to test varies widely. A few states already require the same testing frequency as the proposed regulation. Most states, however, do not require testing at any stated frequency or require testing at most only once per year. It is thus assumed that all the costs of sludge testing are incremental to baseline costs. This assumption somewhat overstates the incremental costs of sludge testing, but this overestimation is not believed to be significant. The actual baseline costs for testing primarily include, in most states, only the costs of testing a few metals at a fairly low frequency per year.

Table 4-26 presents the testing costs for all POTWs not shifting to codisposal. Total annual sludge testing costs are $4.4 million.

Summary of Compliance Costs

As the summary Table 4-27 shows, annual incremental costs for land application under Option 2 total $9.9 million. Total residents served by POTWs using land application are estimated at 29.2 million. Assuming three persons per household, total incremental costs are $1.02 per household per year for POTWs using land application. In addition to the residential population, commercial and industrial customers are also a part of the total population served. The incremental costs, therefore, would be spread over all customers and the actual per-household increment would be reduced.

4.2.4 Costs and Impacts of Regulatory Option 2 Governing the Distribution and Marketing of Sewage Sludge

This section summarizes the impacts of Option 2 on the distribution and marketing of sewage sludge and examines the associated compliance costs. As with the other disposal methods, it is assumed that all POTWs generating noncomposted, 98th percentile sludges will fail the maximum pollutant concentrations for distribution and marketing defined by the 98th percentile

TABLE 4-26

ANNUAL SLUDGE TESTING COSTS FOR LAND-APPLIED SEWAGE SLUDGE UNDER OPTION 2
($1987)

	NO. OF POTWs				TESTING COST/YR		
SIZE	NONCOMPOSTED SLUDGE	COMPOSTED SLUDGE	TOTAL	FREQUENCY OF TESTING	NONCOMPOSTED SLUDGE	COMPOSTED SLUDGE	TOTAL COST
0.1 MGD	1,066	0	1,066	1/yr	$ 848	NA	$ 903,968
0.5 MGD	868	1	869	1/yr	848	1,003	737,067
2 MGD	566	25	591	4/yr	3,392	4,012	2,020,172
14 MGD	62	3	65	1/mo	10,176	12,036	667,020
128 MGD	7	0	7	1/mo	10,176	NA	71,232
Total	2,569	29	2,598[a]				$4,399,459

[a] Total does not include 25 POTWs expected to shift to codisposal.

Source: ERG estimates.

2042S

TABLE 4-27

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWS PRACTICING LAND APPLICATION UNDER OPTION 2

($1987)

		COST OF SHIFTS TO ALTERNATIVE DISPOSAL PRACTICES				
			NONAGRICULTURE			
SIZE	SLUDGE TESTING COSTS	AGRICULTURE	DEDICATED SITE	RECLAMATION	OTHER	TOTAL
0.1 MGD	$ 903,968	$ 8,976	$ 0	$ 0	$ 7,480	$ 920,424
0.5 MGD	737,067	197,136	10,434	50,838	96,570	1,092,045
2 MGD	2,020,172	2,756,330	290,140	145,070	435,210	5,646,922
14 MGD	667,020	1,523,724	0	0	0	2,190,744
128 MGD	71,232	0	0	0	0	71,232
Total	$4,399,459	$4,486,166	$300,574	$195,908	$539,260	$9,921,367

Source: ERG estimates.

sludge profile. Sludge application rates are not relevant to these criteria. POTWs practicing distribution and marketing of sewage sludge have been distinguished from land application for analytical purposes strictly on the basis of whether the sludge has been composted. Thus only POTWs that compost their sludge are currently counted as practicing distribution and marketing. Since composted sludge is diluted, which reduces the pollutant concentrations below those of the 98th percentile criteria, no POTWs in this group will fail the 98th percentile criteria. All these POTWs must, however, meet sludge product labeling and sludge testing requirements.

4.2.4.1 Sizes and Numbers of POTWs Affected by Option 2 Requirements for Distribution and Marketing

A total of 106 POTWs practice distribution and marketing. None are expected to shift to alternative disposal methods in order to comply with Option 2 requirements, but certain management practices must be followed. Compliance costs are thus incurred.

4.2.4.2 Compliance Costs

Compliance costs under Option 2 for POTWs practicing distribution and marketing are limited to the costs of providing labels or handouts to accompany the distributed sludge and the costs of sludge testing. These costs are presented below.

Labeling/Handout Requirements

Although a few states already require labeling or handouts, all the necessary information may not be included on the existing handouts or labels. Additions may have to be made to comply with the proposed regulations in these circumstances. The majority of POTWs using distribution and marketing will have to develop this material. It was assumed that 16 hours of the assistant superintendent's and 4 hours of a clerical staff person's time would be needed to fulfill labeling requirements each year. Hourly labor rates are assumed to be $14.42 and $10.49, respectively. In addition, copy charges for 500 one-page printed handouts at $0.10 per page were allotted. The total annual cost per POTW is $324. If states already require labeling, only a portion of these costs will be relevant.

It is assumed that all POTWs practicing distribution and marketing (106 POTWs) will incur the cost of labeling. The total cost of meeting labeling requirements is $34,344.

Costs of Sludge Testing

All 106 POTWs will incur testing costs. Testing is to be performed annually for POTWs processing less than 1 MGD wastewater; quarterly for those processing 1 to 10 MGD; and monthly for those processing over 10 MGD. Costs are $18 per metal for nine metals and $823 for all organics. Table 4-28 presents the total testing costs. These costs total $551,600.

Summary of Compliance Costs

Table 4-29 presents the total testing and labeling costs for all POTWs practicing distribution and marketing under Option 2. These costs total $585,944. Total residents served by POTWs using land application were estimated to be 16.3 million. Assuming three persons per household, total incremental costs can be expressed as $0.11 per household per year for POTWs using land application. In addition to the residential population, commercial and industrial customers are also a part of the total population served. The incremental costs, therefore, would be spread over all customers, and the actual per-household increment would be reduced.

TABLE 4-28

ANNUAL SLUGE TESTING COSTS FOR POTWS PRACTICING DISTRIBUTION AND MARKETING UNDER OPTION 2

($1987)

SIZE	NO. OF POTWS	FREQUENCY	TESTING COST	TOTAL
0.1 MGD	5	1/yr	$ 985	$ 4,925
0.5 MGD	27	1/yr	985	26,595
2 MGD	45	4/yr	3,940	177,300
14 MGD	16	1/mo	11,820	189,120
128 MGD	13	1/mo	11,820	153,660
Total	106			$551,600

Source: ERG estimates.

2043S

TABLE 4-29

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWS PRACTICING DISTRIBUTION AND MARKETING UNDER OPTION 2

($1987)

SIZE	NO. OF POTWS	LABELING COST	TESTING COST	TOTAL
0.1 MGD	5	$ 1,620	$ 4,925	$ 6,545
0.5 MGD	27	8,748	26,595	35,343
2 MGD	45	14,580	177,300	191,880
14 MGD	16	5,184	189,120	194,304
128 MGD	13	4,212	153,660	157,872
Total	106	$34,344	$551,600	$585,944

Source: ERG estimates.

4.2.5 Summary of Compliance Costs for Option 2

Table 4-30 summarizes the compliance costs for all disposal methods under Option 2. Total compliance costs are $34.3 million. Costs for incineration are the major portion of these compliance costs at $22.8 million. Compliance costs for land application are the next largest portion of total compliance costs for Option 2 at $9.9 million. POTWs practicing monofilling are expected to incur costs of $929,264. POTWs practicing distribution and marketing incur costs of $585,944. Note that the $34.3 million total compliance cost figure represents first-year costs of compliance under Option 2 since incinerator performance testing and dispersion modeling costs are one-time costs. Annual compliance costs in subsequent years are $32.4 million.

4.3 Costs and Impacts of Regulatory Option 3

Option 3 is the basis for the proposed sewage sludge regulation, Part 503. In this option, the pollutant limits for each sludge disposal method are based on the potential for exposure associated with each method (i.e., risk-based criteria). The only exceptions are the criteria for nonagriculture land application and surface impoundments. In these cases, the 98th percentile sewage sludge concentrations, exactly as for Option 2, are used to define the maximum allowable pollutant concentrations in the sewage sludge.

Option 3 is more stringent than Option 2 since the use of risk-based criteria results in much lower allowable pollutant concentrations in the sewage sludge than those allowed under Option 2 for each disposal method covered by risk-based criteria. Additionally, the regulation requires that a number of management practices be followed, including sludge quality monitoring, recordkeeping, and reporting, that are not required under Option 2. The exact regulatory requirements for each disposal method are summarized below. Compliance costs for each method are also presented.

TABLE 4-30

SUMMARY OF TOTAL COMPLIANCE COSTS FOR OPTION 2
($1987)

SIZE	INCINERATION	MONOFILLS	LAND APPLICATION	DISTRIBUTION AND MARKETING	TOTAL[a]
0.1 MGD	$ 0	$ 3,940	$ 920,424	$ 6,545	$ 930,909
0.5 MGD	26,187	33,210	1,092,045	35,343	1,186,785
2 MGD	2,684,296	788,098	5,646,922	191,880	9,311,196
14 MGD	9,701,137	94,560	2,190,744	194,304	12,180,745
128 MGD	10,435,558	9,456	71,232	157,872	10,674,118
Total	$22,847,178	$929,264	$9,921,367	$585,944	$34,283,753

[a] This total is for first-year costs. Recurring annual costs will not include costs of incinerator performance testing and air dispersion modeling and will total $32,378,871.

Source: ERG estimates.

2031S

4.3.1 Costs and Impacts of Regulatory Option 3 Governing the Incineration of Sewage Sludge

The costs and impacts of the proposed regulations pertaining to sewage sludge incinerators are summarized in this section. Incinerator emissions must meet numerical criteria for eight pollutants; the criteria are based on attaining Incremental Annual Air Quality Criteria (IAAQC) developed by EPA. As for Options 1 and 2, POTWs were divided into two groups - those with existing incinerators and those which are expected to build incinerators as a result of the ban on ocean disposal of sewage sludge. For POTWs with existing incinerators, three retrofit technologies were considered as potential control options to achieve compliance with the metals criteria, under the assumption that sufficient pollutant removals are attained with these systems. The ocean ban POTWs, as before, were assumed to have fabric filters or wet ESPs in place. Additionally, afterburners were considered as potential control options to achieve compliance with total hydrocarbon (THC) emissions limits for both groups of POTWs.

4.3.1.1 Overview of the Proposed Regulation

The proposed regulation requires the owners or operators of sewage sludge incinerators to meet numerical criteria and adhere to certain specified operating procedures. The criteria are maximum allowable pollutant concentrations in sludge based on the feed rates of the incinerator, the incinerator's control efficiency, and the impact of incinerator emissions on air quality in affected areas. These criteria have been derived such that cancer-based MEI risk levels of 10^{-5} can be attained.

Compliance with the proposed criteria is demonstrated using a two-tiered system. At the first tier, the incinerator operator calculates maximum allowable concentrations of pollutants in the sludge based on the sludge feed rate or gas flow rate of the incinerator. Limits for pollutants in the sludge are specified for seven heavy metals, and emission limits for total hydrocarbons are defined (no limits for hydrocarbons in the sludge are specified). If the pollutant concentrations in the sludge (or measured hydrocarbons emissions) fall below the calculated maximum allowable concentration values (or emission limits for hydrocarbons), the incinerator is in compliance with the regulation. If the sludge or emissions concentrations do not meet calculated maximum allowable values, compliance must be demonstrated at Tier 2.

As discussed under Option 1, Tier 2 involves determining the actual pollutant removal efficiencies of the incinerator and the site-specific air dispersion characteristics. These data are obtained by testing incinerator emissions and conducting computerized air dispersion modeling. With these data, more accurate maximum allowable sludge concentrations are calculated. If a facility has particularly good pollutant removal efficiencies and/or air dispersion characteristics, the maximum allowable sludge concentrations calculated at Tier 2 may allow higher levels of pollutants in the sludge than the limits at Tier 1. The ocean ban POTWs, which are expected to have wet ESPs or fabric filters in place, should be able to demonstrate excellent pollutant removal efficiencies at this Tier.

If compliance is not achieved at Tiers 1 and 2, a POTW is assumed to need to upgrade the incinerator pollution control equipment. This analysis evaluates four retrofit technologies. Three of these retrofits are expected to control metals emissions: wet electrostatic precipitators; fabric filters (baghouses); or dry scrubbers in combination with fabric filters. The fourth retrofit, afterburners, is expected to control the emission of hydrocarbons.

The proposed regulations also require minimum operating practices, including monitoring of combustion temperature, exit gas temperature, sludge feed rate, pressure drop through pollution control systems, and oxygen and hydrocarbon concentrations. In addition, monthly sludge testing is required for all the contaminants regulated under this disposal option for POTWs processing greater than 10 MGD. Quarterly testing is required of POTWs processing between 1 and 10 MGD; annual testing is required of POTWs processing less than 1 MGD.

4.3.1.2 Methodology

Compliance costs were estimated using a two-stage process. First, a pass/fail analysis was performed to determine the number of facilities currently in compliance with the proposed criteria. Second, compliance costs were aggregated for monitoring, recordkeeping, other management practice modifications, performance tests, and pollution control systems.

As discussed in Section 4.1.1, the 10 model facilities are used to represent all sewage sludge incinerators. The operating parameters for these models were presented in Table 4-1, and the numbers of POTWs and incinerators represented by each model facility were presented in Tables 4-2 and 4-3. The model facility parameters and the sludge quality profiles, along with pollutant control efficiencies, dispersion factors and Reference Air Criteria for each pollutant, are used to determine which facilities would pass at Tier 1. Facilities estimated to fail at Tier 1 are assumed to incur the costs of emissions testing and air modeling in an attempt to demonstrate compliance at Tier 2.

The pass/fail analysis for Tier 2 uses "typical" values for incinerator control efficiencies instead of the worst-case values specified in the regulation, which were used at Tier 1 (see discussion of typical vs. worst-case control efficiencies in Section 4.1.1). The same procedure for calculating dispersion factors in Option 1 was used to determine dispersion factors at Tier 2 under Option 3. Thus, some additional POTWs are expected to demonstrate compliance at Tier 2. Compliance at this stage cannot be estimated precisely, however, since it depends on detailed site-specific factors at each facility. As under Option 1, it was assumed that all POTWs failing at Tier 2 (after maximum contaminant levels are calculated using typical control efficiencies and more precise dispersion factors) would incur the costs of retrofit controls, except for the ocean ban POTWs, which are assumed to have control devices in place. These POTWs are not analyzed using the "typical" control efficiency values. Rather they are assumed to meet the Option 3 regulatory requirements for metals because of their expected use of wet ESPs or fabric filters.

Compliance with emission limits for THC was estimated somewhat differently than compliance with metals criteria. Compliance with metals criteria was estimated using the three sludge profiles; however, no comparable data on hydrocarbon emissions from sludge incinerators were available. The available data are very limited, so the levels of THC pollutants in emissions of each of the model facilities were assigned based on an analysis of incinerator emissions by Radian Corp., performed for EPA, in which emissions from four incinerators were studied.[11] Each of the 10 model facilities was assigned one of the four concentrations derived in the Radian studies, depending on the type of incinerator (fluid-bed vs. all other types) and size of the unit. All fluid-bed incinerators were assigned a THC concentration of 3.4 ppm. The multiple-hearth and electric furnaces represented by Models 4, 6, and 7 were assigned a concentration of 11.9 ppm; those represented by Models 1, 5, 8, and 10 were assigned 26.9 ppm and those represented by Models 2, 3, and 9 were assigned 173.6 ppm. These concentrations were then compared to the maximum pollutant concentrations calculated using the equation provided by Option 3. When the modeled concentrations exceeded the maximum pollutant concentration calculated using the equation, the model and its associated incinerators are estimated to fail to meet the THC emission limits. All units estimated to fail are assumed to retrofit afterburners to comply with Option 3 requirements.

Current compliance with monitoring and other minimum operating requirements was determined based on existing federal regulations affecting sewage sludge incinerators. Incremental actions, such as sludge testing, were assigned costs according to the current actual costs of procuring the service. The detailed assumptions behind each cost estimate are included in the discussion of the results.

4.3.1.3 Results

Pass/Fail Analysis

The results of the Tier 1 pass/fail analysis are presented in Table 4-31. The sludge feed rate of each of the 10 model facilities was used to calculate the maximum allowable pollutant concentration in the sludge for each model

TABLE 4-31

TIER TWO PASS/FAIL ANALYSIS FOR INCINERATION UNDER OPTION 3

STEP ONE: CALCULATIONS OF MAXIMUM POLLUTANT CONCENTRATIONS

	MODEL FACILITY CATEGORY									
	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN
SLUDGE FEED RATE, mt/DAY	31.60	10.00	13.60	89.40	982.00	153.10	176.70	79.50	9.40	25.30

MAXIMUM POLLUTANT CONCENTRATIONS (mg/kg) BY MODEL FACILITY CATEGORY

POLLUTANT	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN
Nickel	205.5	100.8	126.1	43.2	3.9	31.0	29.5	1321.8	234.4	40.12
Lead	358.6	175.8	220.1	75.3	6.9	54.2	51.5	231.8	409.0	70.2
Chromium	661.7	324.5	406.1	139.0	12.6	99.9	45.1	427.7	754.7	129.5
Cadmium	5.1	2.5	3.1	1.1	0.1	0.8	0.7	3.3	5.8	1.0
Arsenic	17.9	54.6	41.6	6.3	0.6	3.7	3.2	7.1	60.2	22.4
Mercury	101.3	320.0	235.3	35.8	3.3	20.9	18.1	40.3	340.4	126.5
Beryllium	31.6	100.0	73.5	11.2	1.0	6.5	5.7	12.6	106.4	39.5
Total Hydrocarbons	35.1	13.3	12.1	24.5	1.2	11.4	10.2	25.1	87.3	29.9

STEP 2: COMPARISON OF CALCULATED POLLUTANT CONCENTRATIONS WITH SLUDGE PROFILE CONCENTRATIONS

	MODEL FACILITY CATEGORY										CONTAMINANT CONCENTRATIONS IN TYPICAL SLUDGES
	1	2	3	4	5	6	7	8	9	10	
Nickel	P	P	P	F	F	F	F	P	P	F	70.1
Lead	P	F	F	F	F	F	F	F	P	F	265.7
Chromium	P	P	P	F	F	F	F	P	P	F	248.2
Cadmium	F	F	F	F	F	F	F	F	F	F	11.2
Arsenic	P	P	P	P	F	F	F	P	P	P	4.4
Mercury	P	P	P	P	P	P	P	P	P	P	1.7
Beryllium	P	P	P	P	P	P	P	P	P	P	0.8
Total Hydrocarbons											
MH	P	F	P	P	F	F	F	F	F	F	Varies[a]
FB	P	P	P	P	P	P	P	P	P	P	3.4

[a] Models 1, 5, 8, and 10 are estimated to emit 26.9 ppm THC; models 2, 3, and 9 are estimated to emit 173.6 ppm THC; and models 4, 6, and 7 are estimated to emit 11.9 ppm THC.

Source: ERG estimates.

P = Pass
F = Fail

MH = Multiple-hearth/Other
FB = Fluid-bed

category. These values were compared to the estimated pollutant concentrations of the typical sludge profile. If the estimated concentration for any pollutant exceeds the calculated maximum allowable pollutant concentration, the model facility fails to demonstrate compliance at Tier 1. Concentrations of several pollutants exceed the maximum concentration level for all the model categories and, therefore, none of the model facilities would pass at Tier 1, assuming that their sludges contained typical contaminant levels. Since the 90th and 98th percentile sludge profiles contain higher concentrations of all contaminants than typical sludges, the Tier 1 analysis was not repeated for these additional sludge profiles. None of the 169 POTWs now using incineration are thus estimated to be able to comply with the regulations at Tier 1.

At Tier 2, several model facilities are estimated to pass the calculated maximum allowable pollutant concentrations. Table 4-32 presents the results of the Tier 2 pass/fail analysis for typical sludges. As the table shows, all existing facilities except those represented by Models 1 and 9 burning typical sludges fail to meet criteria for metals (62 POTWs with 108 existing incinerators). All multiple-hearth and electric furnaces represented by Models 2, 3, 5, and 8 also fail to meet hydrocarbon emission requirements when burning typical sludge (13 POTWs with 19 existing incinerators). The ocean ban POTWs, since they are assumed to use fluid-bed incinerators equipped with wet ESPs or fabric filters, are estimated to pass all criteria at Tier 2 regardless of sludge quality.

Not included in this table are the results for 90th and 98th percentile sludges incinerated at existing units. All model facilities burning these sludge types fail to meet the pollutant limitation criteria for metals in sludge (60 POTWs with 111 existing incinerators). Models 2, 3, 5, and 8 also fail to meet hydrocarbon emission limitations (15 POTWs with 42 existing incinerators) when burning 90th and 98th percentile sludge. Thus the total number of POTWs and incinerators estimated to fail to meet metals criteria, regardless of sludge type incinerated, is 122 POTWs with 219 existing incinerators. Of these, a total of 28 POTWs with 61 existing incinerators is also estimated to fail to meet hydrocarbon emissions requirements. A total of 47 POTWs with 63 existing incinerators is estimated to meet all incineration criteria.

TABLE 4-32

TIER TWO PASS/FAIL ANALYSIS FOR INCINERATION UNDER OPTION 3

STEP ONE: CALCULATIONS OF MAXIMUM POLLUTANT CONCENTRATIONS

	MODEL FACILITY CATEGORY									
	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN
SLUDGE FEED RATE, mt/DAY	31.60	10.00	13.60	89.40	982.00	153.10	176.70	79.50	9.40	25.30

MAXIMUM POLLUTANT CONCENTRATIONS (mg/kg) BY MODEL FACILITY CATEGORY

POLLUTANT	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN
Nickel	1,613.2	220.0	238.7	141.1	65.4	153.4	122.3	202.2	768.3	377.2
Lead	2,658.4	362.5	393.3	232.5	107.7	252.8	201.5	333.3	1,266.0	621.7
Chromium	5,534.8	754.6	818.8	484.1	224.3	526.3	419.6	693.9	2,635.9	1,294.5
Cadmium	36.1	4.9	5.3	3.2	1.5	3.4	2.7	4.5	17.2	8.4
Arsenic	121.7	16.6	18.0	10.6	4.9	11.6	9.2	15.3	58.0	28.5
Mercury	101.3	320.0	235.3	35.8	3.3	20.9	18.1	40.3	340.4	126.5
Beryllium	31.6	100.0	73.5	11.2	1.0	6.5	5.7	12.6	106.4	39.5
Total Hydrocarbons	181.2	19.2	15.1	52.8	13.7	37.2	27.8	25.1	188.2	184.3

STEP 2: COMPARISON OF CALCULATED POLLUTANT CONCENTRATIONS WITH SLUDGE PROFILE CONCENTRATIONS

	MODEL FACILITY CATEGORY										CONTAMINANT CONCENTRATIONS IN TYPICAL SLUDGES
	1	2	3	4	5	6	7	8	9	10	
Nickel	P	P	P	F	F	F	F	P	P	P	70.1
Lead	P	P	P	F	F	F	F	P	P	P	265.7
Chromium	P	P	P	F	F	F	F	P	P	P	248.2
Cadmium	P	F	F	F	F	F	F	F	P	P	11.2
Arsenic	P	P	P	P	P	F	F	F	P	P	4.4
Mercury	P	P	P	P	P	P	P	P	P	P	1.7
Beryllium	P	P	P	P	P	P	P	P	P	P	0.8
Total Hydrocarbons											
MH	P	F	F	P	F	P	P	F	P	P	Varies[a]
FB	P	P	P	P	P	P	P	P	P	P	3.4

[a] Models 1, 5, 8, and 10 are estimated to emit 26.9 ppm THC; models 2, 3, and 9 are estimated to emit 173.6 ppm THC; and models 4, 6, and 7 are estimated to emit 11.9 ppm THC.

Source: ERG estimates.

P = Pass
F = Fail

MH = Multiple-Hearth/Other
FB = Fluid-Bed

4.3.1.4 Compliance Costs

Compliance costs will include the costs of meeting the management practice requirements, the costs of testing incinerator emissions and modeling air dispersion, and the costs of retrofit control technologies.

Costs of Complying With Management Practices Requirements

The required management practices apply to all sewage sludge incinerators and include sludge testing for all regulated contaminants and continuous monitoring and recording of several incinerator operating parameters. Recordkeeping and reporting tasks are also required. The derivation of total costs associated with these requirements is discussed below.

Continuous Monitoring and Recordkeeping. The proposed regulations specify continuous monitoring and recording of several operating parameters. The New Source Performance Standards (NSPS), as required by the Clean Air Act, require much of the same types of monitoring and recording activities as those required under Option 3. The baseline for determining current compliance with these requirements includes the incinerators covered by NSPS. The following assumptions regarding baseline monitoring and recording were based on expert opinion, vendor quotations, and EPA data on equipment costs.[12] These costs also include labor costs for calibrating equipment and collecting data.

- Continuous monitoring and recording of sludge feed rate to the incinerator. All existing plants are assumed to have sludge feed rate monitors. Those plants covered by NSPS must continuously monitor and record feed rates. A few plants not covered by NSPS may not have continuous recorders and may have to add this equipment at a cost of approximately $837 per unit annually. Thirty percent of all POTWs with existing incinerators are covered by NSPS, thus seventy percent of existing units are expected to add feed rate recorders to each unit at a total cost of about $160,000. Ocean ban POTWs are covered by NSPS, so none of these incinerators will require feed rate recorders.

- Continuous monitoring and recording of furnace temperature. Seventy percent of existing incinerators are assumed to have these devices already. For those which do not, two thermocouples for each of eight hearths for multiple-hearth furnaces, and two thermocouples each for the drying, combustion, and cooling zones for other types of incinerators were assumed. A total of 240 out of 282 existing incineration units are multiple-hearth furnaces. The annual costs per unit for these devices are $1,642 for multiple-hearth units and $1,447 for other incinerators. For the units out of compliance, costs of adding furnace temperature monitors are approximately $140,000. All ocean ban POTWs are assumed to have these devices in place.

- Continuous monitoring and recording of the scrubber pressure drop. Thirty percent of the existing units are assumed to have pressure monitors and recording devices. For those which do not, the annual costs per unit are $1,090 for the monitor and $837 for the recorder, including paper. For the units out of compliance, costs of adding pressure drop monitors to existing units are approximately $380,000. All ocean ban POTWs are assumed to have these devices in place.

- Continuous monitoring and recording of the temperature of combustion gases exiting the unit. To meet this requirement, two thermocouples per unit were assumed. The cost of the sensing and recording devices (including maintenance) is $1,370 annually. Thirty percent of the existing units are assumed to have such devices already. For the units out of compliance, costs of adding combustion gas temperature monitors are approximately $270,000. All ocean ban POTWs are assumed to have these devices in place.

- Oxygen monitors. Thirty percent of the existing units are assumed to have these devices. The annual cost of the monitor (including maintenance) is $6,294. For the units out of compliance, costs of adding oxygen monitors are approximately $1.2 million. All ocean ban POTWs are assumed to have these devices in place.

- Continuous monitoring and recording of total hydrocarbon concentrations in the incinerator stack. None of the units, either existing or projected, are assumed to have these devices. The annual cost of the monitor (including maintenance) is $6,000 per unit. Costs of adding total hydrocarbon monitors are approximately $1.7 million for existing units and $204,000 for the ocean ban incinerators.

The incremental costs of continuous monitoring and recording for all POTWs with existing and projected incinerators are estimated to be $4.1 million annually (see Table 4-33). These costs reflect annualized capital plus annual operating and maintenance expenses.

Emissions Performance Tests and Air Dispersion Modeling

If POTWs incinerating sludge do not pass the Tier 1 criteria, they will have to conduct an emissions performance test and air dispersion modeling. At the time of the test, the sludge contaminant levels must be determined and

TABLE 4-33

ANNUAL COSTS OF MONITORING SEWAGE SLUDGE INCINERATION UNDER OPTION 3

($1987)

	MODEL FACILITY[a]										
SIZE	1	2	3	4	5	6	7	8	9	10	TOTAL
0.5 MGD	$ 16,428	$ 0	22,428	$ 0	$ 0	$ 95	$ 0	$ 0	$ 0	$ 0	$ 38,951
2 MGD	429,804	153,960	350,060	0	0	24,519	194,653	16,428	56,926	24,070	1,250,420
14 MGD	395,696	23,825	97,424	143,922	0	458,467	397,338	62,926	56,926	24,070	1,660,644
128 MGD	70,428	0	24,070	97,424	235,346	162,910	212,918	244,350	0	97,424	1,144,870
Total	$912,356	$177,835	$493,982	$241,346	$235,346	$645,991	$804,909	$323,704	$113,852	$145,564	$4,094,885

[a] Totals for each model facility reflect the number of incinerators in each size class represented by the model facility and are thus the total incremental costs for all incinerators of that size corresponding to that model facility. Costs for ocean ban POTWs were distributed, when a central facility was indicated, based on proportion of sludge contributed by POTWs in each size category.

Source: ERG estimates.

other relevant operating conditions, such as sludge feed rate and combustion temperatures, must be recorded. They must then assemble the data and prepare a report of the performance test results.

Table 4-34 summarizes the aggregate costs of performance testing. Since all incinerators fail at Tier 1, these costs are assumed to be incurred by all existing facilities. The ocean ban POTWs are, however, believed likely to perform these tests to meet state requirements, to alleviate public concerns or to respond to anticipated state or federal requirements. Although the performance testing is costly, it is assumed that a POTW with existing incinerators will attempt to demonstrate compliance at this stage before expensive installing retrofit pollution control equipment. The assumptions regarding the incremental costs of performance testing per facility are as follows:

- Sludge testing during emissions testing is assumed to be incorporated as part of the POTW's regular testing schedule. Thus no testing costs incremental to those presented below under sludge quality monitoring, recordkeeping and reporting are assumed.
- Emissions tests must be conducted for those pollutants that fail to meet the Tier 1 criteria. Only metals are assumed to be tested, since total hydrocarbon limits are not based on control efficiencies, only on gas flow rates and dispersion factors. Most of the cost of emissions testing is associated with stack sampling. The cost is approximately the same whether one or seven metals are analyzed. One incinerator test for metals (including costs for sampling, analysis, and report preparation) averages about $11,400 based on discussions with companies providing this service. Costs for testing additional incinerators (where a POTW has more than one in operation) would add an average of $1300 per incinerator for metals analysis. It is also assumed that 2 additional days with a 2-person crew would be required to complete the additional sampling on each incinerator at an average of about $400/day/person or $1600. An added $600/incinerator for report preparation by the stack sampling firm is also assumed. Thus a total of $3500 per additional incinerator is estimated to be incurred.
- Costs associated with supervision of the emissions testing, data assembly, and additional report writing are assumed based on 24 hours of the assistant superintendent's time and 8 hours of clerical staff time. Hourly labor rates are $14.46 for the assistant superintendent and $10.49 for clerical staff. This is $431 per POTW.

TABLE 4-34

AGGREGATE COSTS OF INCINERATOR PERFORMANCE TESTING UNDER OPTION 3
($1987)

SIZE	NO. OF POTWS	NO. OF INCIN- ERATORS	EMISSION TESTING COSTS FOR ONE INCINERATOR	EMISSION TESTING COSTS FOR ADDITIONAL INCINERATORS	DISPERSION MODELING COST	TOTAL SUPERVISION, DATA ASSEMBLY, AND REPORTING	TOTAL COSTS FOR PER- FORMANCE TESTS AND DISPERSION MODELING
0.1 MGD	0	0	$ 0	$ 0	$ 0	$ 0	$ 0
0.5 MGD	3	3	34,200	0	3,000	1,293	38,493
2 MGD	71	90	809,400	66,500	71,000	30,601	977,501
14 MGD	76	120	866,400	154,000	76,000	32,756	1,129,156
128 MGD	19	69	216,600	175,000	19,000	8,189	418,789
Total	169	282	$1,926,600	$395,500	$169,000	$72,839	$2,563,939

Source: ERG estimates.

Dispersion modeling for each facility is conducted by an air modeling consultant at a cost of $1,000 for modeling one incinerator, which accounts for 16 hours of work at approximately $60 per hour.

Total costs associated with performance testing and dispersion modeling to demonstrate compliance at Tier 2 are $2.6 million for existing facilities. These costs are one-time expenditures incurred by all POTWs with existing incinerators that want to avoid the cost of retrofit pollution control devices.

Sludge Quality Monitoring, Recordkeeping and Reporting. Most POTWs very likely perform some sludge testing of common heavy metals (e.g., cadmium or chromium), but the extent of current testing among POTWs with sludge incinerators has not been documented. No federal regulations address this practice, and EPA is unaware of such requirements among the states. The state of New Jersey requires sludge testing as part of the permitting process, but it is not clear whether continued testing is required. It was assumed conservatively that all sludge testing performed to comply with the proposed regulations would be entirely new activity. Actual testing costs may be overestimated because baseline sludge testing is not accounted for. This overestimation, however, is judged to be small. All recordkeeping costs are also assumed to be incremental for both groups of POTWs.

Sludge quality monitoring costs were assumed to be $15 per metal (seven metals are regulated). Specific organic analyses were not required. The costs reflect the average charges to obtain sludge testing services at independent testing laboratories. Some POTWs may have in-house laboratories capable of providing needed testing services at a lower cost. The total annual cost of sludge monitoring for all POTWs with incinerators is $176,505 (see Table 4-35).

All of the results of the sludge quality testing, the continuous monitoring of incinerator operating parameters, calibration records, incinerator performance tests, and air dispersion modeling must be kept on file. This is estimated to be primarily a clerical task requiring about 50 hours annually per incinerator at a rate of $10.49 per hour, or a total of $525 per incinerator per year.

TABLE 4-35

ANNUAL COSTS OF SLUDGE QUALITY MONITORING, RECORDKEEPING AND REPORTING FOR INCINCERATION UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS EXISTING	OCEAN BAN	MONITORING AND REPORTING FREQUENCY	SLUDGE QUALITY MONITORING COST/YR	RECORD-KEEPING COSTS/YR	REPORTING COST/YR	TOTAL COST
0.1 MGD	0	0	1/yr	$ 0	$ 0	$ 0	$ 0
0.5 MGD	3	2	1/yr	525	2,625	750	3,900
2 MGD	71	3	4/yr	31,080	38,850	44,400	114,330
14 MGD	76	6	1/mo	103,320	43,050	147,600	293,970
128 MGD	19	14	1/mo	41,580	17,325	59,400	118,305
Total	169	25		$176,505	$101,850	$252,150	$530,505

Source: ERG estimates.

2091S

POTWs must also provide reports detailing the results of the sludge quality testing, the calibration records, incinerator performance tests, and air dispersion modeling, as well as special reports required when the operating parameters fall outside the allowable range, the recordings for total hydrocarbon concentrations and recordings for the sewage sludge feed rate. Testing laboratories provide results of the sludge quality tests, and reporting costs have already been included in the costs of incinerator performance tests and air dispersion modeling. Thus the major costs of these reports are the clerical time to organize and copy charges for the calibration records, special reports and continuous recording charts for hydrocarbons and sludge feed rates. These reports must be prepared at the same frequency as the sludge quality testing. It is assumed that the reports require 2 hours of supervisory time at $14.46 per hour and 10 hours of clerical time at $10.49 per hour and $20 ($0.10 per page for 200 pages) in copying charges for a total of about $150 per POTW per reporting period. Table 4-35 shows the costs for recordkeeping and reporting, along with the costs for sludge quality monitoring. Total costs for all these management practice requirements are $530,505 annually.

Cost for all management practice requirements include costs for continuous monitoring and recording of incinerator parameters, incinerator performance tests, air dispersion modeling, sludge quality monitoring, recordkeeping and reporting. These costs total $7.2 million in the first year and $4.6 million in subsequent years.

Control Technology Options

A description of the particulate control devices considered in this analysis (wet ESPs, fabric filters, and dry scrubbers with fabric filters) were discussed in detail in Section 4.1.1.3. Control of hydrocarbon emissions was not required under Options 1 and 2, but is required under Option 3. Afterburners must therefore be considered as an additional pollution control device.

Afterburners can be used to control volatile organic emissions. These devices operate at high temperatures and retain flue gases to destroy a high percentage of volatile organic compounds. Control efficiencies of 98 to 99 percent are expected. This analysis assumes that the afterburners heat gases to 1400°F with a 0.5-second retention time. Afterburners are not necessary with fluid-bed furnaces because of the high temperatures already achieved by this type of incinerator. Multiple-hearth and electric furnaces may, however, benefit from the installation of these devices.

Afterburners would be installed in a multiple-hearth or electric furnace immediately in back of the incinerator (see Figures 4-1 through 4-6 for the various furnace configurations). In some installations, it may be possible to install an afterburner in the top hearth of a multiple-hearth furnace if this hearth is not used in the burning process. This type of installation can be performed if the sludge has been dewatered to a high degree, making the top hearth, which is normally used for drying, unnecessary. The flue gases, which have been raised to a temperature of 1400°F, must be cooled to 400°F before they enter the pollution control device. For fabric filters, a quench chamber, which uses less water than a venturi, is used for this purpose, since gases that are too wet will cake the filter material of the fabric filter. When wet ESPs are retrofit, the venturi can be left in place, since these devices are not incompatible with the operation of the wet ESP. The afterburner immediately follows the incinerator, as in the case with the fabric filter setup, and the wet ESP follows the afterburner and the venturi/impingement plate aftercooler. As noted above, fluid-bed incinerators should not require afterburners. Afterburners may also be unnecessary with dry scrubber/fabric filter systems, although data are not sufficient to verify this.

Costs of Control Equipment Retrofits

Three technologies were considered for retrofit options to control metals emissions: (1) wet electrostatic precipitators; (2) fabric filters; and (3) dry scrubbers with fabric filters. These technologies were described in detail in Section 4.1.1.4. Aggregate costs of the three retrofit technology options are presented in this section. As noted above, these technologies are expected to be primarily effective in removing metals from incinerator emissions. Afterburners must be installed to effect removal of hydrocarbons. Thus the 26 POTWs with 44 existing incinerators estimated to fail to meet hydrocarbon emission limits may require afterburners. A very small number of incinerators currently have afterburners installed, but none are currently believed to be running their afterburners. It is thus assumed that all facilities failing hydrocarbon criteria will have to retrofit afterburners. This assumption should not significantly overstate costs, since operating costs are the major component of the annual cost of afterburners. A total of 122 POTWs with 219 existing incinerators are also estimated to fail the criteria for metals at Tier 2, thus the retrofit costs will reflect the installation of metal emissions control technologies on these incinerators. No ocean ban POTWs are estimated to require any retrofit equipment.

Engineering estimates were used to develop the unit costs of each retrofit. The number of units for each type of incinerator in each size category was estimated using equipment supplier lists and field records. All incinerators were assumed to operate at 70 percent capacity utilization. As discussed in Section 4.1.1, this assumption may not be appropriate for some plants, but was used to represent average incinerator operations.

Total annual costs of retrofit technologies include annualized capital costs, installation and engineering expenses, and yearly operation and maintenance costs. The annual costs for metal emissions control technology are first presented assuming that all incinerators retrofit one type of pollution control device, either fabric filters, wet ESPs, or dry scrubbers with fabric filters. This presentation allows a range of retrofit costs to be calculated. Following these estimates, a point estimate is derived for purposes of the analysis, assuming only wet ESPs are chosen by all POTWs whose incinerators fail to meet the metals criteria. Subsequently, costs for afterburners are estimated and total costs for all pollution control devices are then presented.

Costs of Controlling Metal Emissions. The total costs for controlling metals emissions vary depending on what control technology is chosen. If all POTWs choose the wet ESP option, costs for retrofitting metal emission pollution control equipment are $24.0 million (see Table 4-36). The costs associated with the addition of fabric filters are $21.5 million (see Table 4-37). The most expensive option is the dry scrubber/fabric filter option which is estimated to cost $186.2 million (see Table 4-38). (Note that dry scrubber/fabric filter retrofit costs for electric furnaces were not developed and, therefore, retrofit costs for these five units were assumed equal to those for multiple-hearth furnaces.) These costs show the potential range of pollution control costs for metals that might be incurred under Option 3: $21.5 to $186.2 million.

For purposes of deriving a point estimate, wet ESPs have been assumed to be installed on all incinerators that fail to meet criteria for metals. Additionally, it has been assumed (since data to confirm or dispute the ability of wet ESPs to achieve the necessary pollutant removal are lacking) that wet ESPs can achieve the necessary control efficiencies required to meet the criteria for metals in sludge. For many incinerators, installing a wet ESP is often the most practical option for several reasons. First, since the venturi/impingement systems can be left intact with the wet ESP, gas flows entering the wet ESP will be reduced (the gas will be at a lower temperature; thus, it will have less volume). Smaller equipment than that needed for a comparable fabric filter system will then be necessary. Second, in the case of a wet ESP, equipment dismantling and removal costs are avoided if the existing scrubber remains. Ash slurry from the wet ESP can be returned to the headworks of the plant for treatment. Fabric filters require separate ash handling equipment and disposal.

It is thus estimated that the costs for installing control technologies on all incinerators that fail to meet the metals criteria are the costs of installing wet ESPs, or $24.0 million annually.

TABLE 4-36

COST OF UPGRADED POLLUTION CONTROL SYSTEMS
TOTAL ANNUAL COST OF ELECTROSTATIC
PRECIPITATORS UNDER OPTION 3
($ 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			ELECTRIC FURNACES			
SIZE	NO. UNITS	UNIT COST WET ESP	TOTAL COST	NO. UNITS	UNIT COST WET ESP	TOTAL COST	NO. UNITS	UNIT COST WET ESP	TOTAL COST	GRAND TOTAL COSTS WET ESP
0.5 MGD	1	$ 23,013	$ 23,013	0	$17,954	$ 0	1	$16,364	$ 16,364	$ 39,377
2 MGD	35	53,905	1,886,674	22	37,155	817,400	2	26,483	52,966	2,757,039
14 MGD	84	115,343	9,688,795	7	55,354	387,475	0	48,600	0	10,076,270
128 MGD	67	166,681	11,167,617	0	95,118	0	0	0	0	11,167,617
Total	187		$22,766,099	29		$1,204,875	3		$ 69,330	$24,040,303

Source: ERG estimates.

2094S

TABLE 4-37

COST OF UPGRADED POLLUTION CONTROL SYSTEMS
TOTAL ANNUAL COST OF FABRIC FILTERS
UNDER OPTION 3
($ 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			ELECTRIC FURNACES			
SIZE CLASS	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL COST	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL COST	NO. UNITS	ANNUAL UNIT COST FABRIC FILTERS	TOTAL COST	GRAND TOTAL ANNUAL COSTS FABRIC FILTERS
0.5 MGD	1	$ 17,139	$ 17,139	0	$ 28,767	$ 0	1	$ 10,611	$ 10,611	$ 27,749
2 MGD	35	47,826	1,673,910	22	47,354	1,041,787	2	24,893	49,786	2,765,483
14 MGD	84	101,239	8,504,075	7	65,207	456,448	0	62,390	0	8,960,523
128 MGD	67	145,311	9,735,812	0	95,118	0	0	45,945	0	9,735,812
Total	187		$19,930,936	29	$236,446	$1,498,235	3		$ 60,396	$21,489,567

Source: ERG estimates.

TABLE 4-38

COST OF UPGRADED POLLUTION CONTROL SYSTEMS
TOTAL ANNUAL COST OF DRY SCRUBBERS
UNDER OPTION 3
($ MILLIONS 1987)

	MULTIPLE-HEARTH FURNACES			FLUID-BED FURNACES			
SIZE CLASS	NO. UNIT[a]	ANNUAL UNIT COST DRY SCRUBBERS	TOTAL COST	NO. UNITS	ANNUAL UNIT COST DRY SCRUBBERS	TOTAL COST	GRAND TOTAL ANNUAL COST DRY SCRUBBERS
0.5 MGD	2	$0.14	$ 0.27	0	$0.13	$ 0.00	$ 0.27
2 MGD	37	0.33	12.03	22	0.28	6.23	18.26
14 MGD	84	0.79	66.09	7	0.45	3.16	69.24
128 MGD	67	1.47	98.40	0	0.71	0.00	98.40
Total	190		$176.79	29		$ 9.39	$186.18

[a] Includes three electric furnaces.

Source: ERG estimates.

Costs of Controlling Hydrocarbon Emissions. An estimated 26 POTWs are assumed to require afterburners on a total of 44 existing incinerators to control hydrocarbon emissions. Ocean ban POTWs, which are assumed to have constructed fluid-bed incinerators, are not estimated to require afterburners. Costs of retrofitting the afterburners to the 44 existing units are presented in Table 4-39 and total $80.6 million. Afterburner costs may, however, be reduced by installing energy recovery equipment. This equipment adds to capital costs but reduces the fuel costs associated with operating afterburners. Since fuel costs are the major component of annual costs, a reduction in this cost could potentially more than offset the increased capital costs.

There are three feasible methods for recovering energy from hot gases leaving afterburners installed on multiple-hearth or electric furnaces: (1) preheating combustion air for sludge incineration; (2) installing a waste heat boiler; and (3) preheating gases entering the afterburner with the afterburner exhaust gas.

- Preheating Combustion Air for Sludge Incinerators. Gas-to-air heat exchangers may be used to preheat air for sludge combustion. Warm air leaving the center shaft of the furnace can be heated with a heat exchanger to about 1,200°F and then returned to the furnace as combustion air. Such a system requires a tight furnace to minimize air leaks as well as hot-air gas ducting to various hearths for proper distribution and control of preheated air. New furnace doors may be needed and some welding might be required to allow tight control of intake air.

  For estimating the value of heat recovery, a heat and mass balance was computed with 1,200°F preheated air temperature instead of 700°F as originally assumed. The computation indicates a 30 to 40 percent savings in fuel consumption.

  The capital and installation costs for heat exchange equipment will vary with the configuration of the existing equipment and available space in the building. These costs are estimated to be $160,000 to $800,000 per unit for the range of multiple-hearth furnace sizes analyzed in this study.

- Waste Heat Boiler. Installation of a waste heat recovery boiler is a feasible and practical method of recovering energy from gases leaving afterburners. Recovered energy could provide building heat, air conditioning, and power for rotating equipment, or could be used to generate electricity. Use of the steam from the waste heat boiler depends on specific plant needs and requires additional equipment such as steam turbines or evaporative air conditioners. The comparable value of the recoverable energy could substantially offset the cost of fuel required to operate afterburners if all the produced steam can be used.

  The capital cost for equipment and installation of a waste heat boiler, excluding equipment for steam utilization, could range between $260,000 and $1,800,000 for each furnace, depending on the furnace size, the existing configuration, and building limitations.

- Preheating Gases with Afterburner Exhaust Gas. Fuel savings could potentially be achieved if afterburner exhaust gases were used to preheat gases entering the afterburner. The temperature gradient between typical furnace gas exhaust (700°F) and afterburner exhaust (1,400°F) is not large enough, however, to significantly raise the temperature of the gases entering the afterburner. Also, no proven equipment for this process exists. The process requires heat exchangers to handle ash-laden gases on both sides of the heat exchanger. If a heat exchanger were installed downstream of the scrubber followed by the afterburner, however, clean gas from the scrubber could be heated with the hot gas leaving the afterburner. This configuration will be economically feasible only if clean gas from the scrubber is subcooled to at least 80°F to rid the gas of excess moisture.

  Such a system will consume about 50 percent less fuel than a conventional afterburner installed downstream of the multiple-hearth furnace. This configuration requires, however, additional stages in the impingement plate scrubber for additional cooling and a heat exchanger. Since the pressure drop for the system would be increased with the additional equipment, a new induced-draft fan may also be required.

  The capital and installation costs for such a system will be at least 50 percent higher than the cost for a conventional afterburner system as originally described.

In conclusion, there are ways to reduce operating costs for afterburners installed on multiple-hearth and electric furnaces, but the systems for energy recovery require additional capital and installation costs. Moreover, the application of these energy recovery systems are site specific and depend on equipment size, existing configuration, building limitations, ability to use recovered energy, and compatibility with equipment operating schedules.

Despite these drawbacks, it is conservatively assumed that a 10 percent net annual cost savings can be realized at a minimum when some form of energy recovery system is used. These cost savings are reflected in Table 4-38. Total costs for afterburners are thus estimated to be $72.6 million annually.

Total Costs of Pollution Control Equipment. Assuming that wet ESPs are retrofitted to all incinerators estimated to fail to meet metal emissions criteria and that afterburners with heat exchangers are retrofitted to all incinerators estimated to fail to meet hydrocarbon emission limits, the total costs of all pollution control equipment are $64.2 million. These costs may range from $61.7 million to $226.4 million if fabric filters or dry scrubbers plus fabric filters are retrofit instead of wet ESPs.

Summary of Compliance Costs

Table 4-40 presents the aggregate compliance costs associated with incineration, including management practice costs, performance testing costs, dispersion modeling costs, and retrofit technology costs (wet ESPs and afterburners). Compliance costs total $103.8 million. Note that performance testing and dispersion modeling costs are one-time costs. Thus the $103.8 million figure is a first-year cost. Recurring costs in subsequent years are $101.2 million annually.

The total residential population served by POTWs using existing incinerators is 24.9 million. Assuming three persons per household, the first-year incremental costs are $12.48 per household based on the incremental costs of compliance for POTWs with existing incinerators provided in the footnote to Table 4-40. Annual incremental costs in subsequent years for households served by existing incinerators are $12.17 per household. The ocean ban POTWs are estimated to incur costs of $281,895 or about $0.09 per household based on a residential population of 9.9 million. Actual

TABLE 4-39

COSTS OF UPGRADED POLLUTION CONTROL SYSTEM
TOTAL ANNUAL COST OF AFTERBURNERS UNDER OPTION 3
($1987)

	MULTIPLE-HEARTH FURNACES			ELECTRIC FURNACES				
SIZE CLASS	NO. UNITS	ANNUAL UNIT COST OF AFTERBURNERS	TOTAL COST	NO. UNITS	ANNUAL UNIT COST OF AFTERBURNERS	TOTAL COST	GRAND TOTAL ANNUAL COSTS AFTERBURNERS	TOTAL WITH HEAT EXCHANGERS/ ENERGY RECOVERY
0.5 MGD	1	$ 154,937	$ 154,937	1	$123,992	$123,992	$ 278,929	$ 251,036
2 MGD	17	305,049	5,185,836	2	123,992	247,984	5,433,820	4,890,438
14 MGD	10	1,141,102	11,411,022	0	280,922	0	11,411,022	10,269,920
128 MGD	30	2,117,197	63,515,901	0	405,542	0	63,515,901	57,164,311
Total	58		$80,267,697	3		$371,975	$80,639,672	$72,575,705

Source: ERG estimates.

TABLE 4-40

SUMMARY OF COMPLIANCE COSTS FOR INCINERATION UNDER OPTION 3

($1987)

SIZE	SLUDGE TESTING, RECORD-KEEPING, AND RE-PORTING	MONITORING	PERFORMANCE TESTING AND DISPERSION MODELING	POLLUTION CONTROL EQUIPMENT FOR METALS	AFTERBURNERS	COMPLIANCE COSTS[a]
0.1 MGD	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
0.5 MGD	3,900	38,951	38,493	39,377	251,036	371,757
2 MGD	114,330	1,250,420	977,501	2,757,039	4,890,438	9,989,728
14 MGD	293,970	1,660,644	1,129,156	10,076,270	10,269,920	23,429,960
128 MGD	118,305	1,144,870	418,789	11,167,617	57,164,311	70,013,892
Total	$530,505	$4,094,885	$2,563,939	$24,040,303	$72,575,705	$103,805,337

[a] This total is for first-year costs. Recurring annual costs will not include costs of incinerator performance testing and dispersion modeling and will total $101,241,398. For POTWs with existing incinerators, total first-year costs are $103,523,442, with recurring costs of $100,959,503.

Source: ERG estimates.

per-household costs would be somewhat lower because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

4.3.2 Costs and Impacts of Regulatory Option 3 Governing Disposal of Sewage Sludge in Landfills

This section summarizes the costs and impacts of regulatory Option 3 on the disposal of sewage sludge in monofills. Incremental requirements governing the codisposal of sewage sludge in municipal landfills are not included in any of the regulatory options. Codisposed sludge is covered as a part of regulations in 40 CFR Part 257 and proposed Part 258, which govern Subtitle D disposal. The section of the proposed sewage sludge regulations regarding sludge monofills incorporates sections of the proposed Part 258 RCRA amendments, but also contains mandates unique to this rulemaking. In general, sludge monofills are not covered under Part 258, but those accepting septage pumped from household septic tanks would be covered under Part 258.

4.3.2.1 Overview of the Proposed Regulations

The proposed Option 3 regulations governing monofills include numerical criteria, siting requirements, and management practices requirements designed to minimize adverse effects to human health and the environment. The proposed regulation affects owners and operators of sewage sludge monofills that are on or separate from the POTW site. EPA has identified 49 POTWs that use or maintain a sludge monofill. A few POTWs share one monofill, but most operate their own onsite or offsite monofill (see Table 3-15 in Section Three). These POTWs account for 101,375 metric tons of sludge per year.

One set of numerical criteria is specified for monofills located over Class I ground water aquifers. Class I ground waters are highly vulnerable to contamination and are either irreplaceable sources of drinking water to substantial populations or ecologically vital. Another set of numerical criteria is specified for Class II and Class III ground waters. Class II ground waters are or may become sources of drinking water; Class III ground waters are not sources of drinking water.

The criteria for monofills located over Class I groundwater specify maximum sewage sludge concentrations of priority toxic pollutants for 6 metals and 12 organics (Class I criteria) and for 4 metals and 11 organics (Class II and III criteria). Sludge testing is required at varying frequencies based on POTW size. POTWs processing less than 1 MGD must test annually; those processing 1 to 10 MGD must test quarterly; and those processing more than 10 MGD must test monthly.

If a POTW's sludge does not meet the numerical criteria for one or more pollutants, the owner or operator may, at his/her own expense have EPA run a computer model to generate criteria based on the POTW's own site characteristics. New pollutant limits would be generated for this specific site. Assuming the sludge meets the new criteria and all other monofill requirements are met, the POTW would be able to dispose of this sludge in the specified monofill.

The siting requirements restrict the operation of landfills in floodplains; wetlands; seismic zones; fault zones; unstable and unmonitorable areas; and areas located near airports. These siting restrictions are also set forth in the proposed Part 258 amendments for solid waste landfills.

The proposed regulation specifies management practices that define minimum acceptable operating procedures for monofills. The following items are addressed: cover material, explosive gases (including methane monitoring), access, run-on/run-off control systems, closure plans, corrective action plans and recordkeeping and reporting. These management practices are the same or equivalent to those proposed in Part 258 for those monofills accepting septage.

4.3.2.2 Methodology

The analysis of compliance costs proceeded in two stages. First, an evaluation of the numerical criteria was performed to determine how many POTWs would meet these limits. Second, the costs of complying with the criteria and the management practices were compiled for all POTWs passing the criteria.

The criteria were analyzed using the three sludge concentration profiles established in Section Three of this report to represent POTWs with typical sludges, 90th percentile sludges, and 98th percentile sludges. The POTWs known to use sludge monofills were assigned to these three groups based on the percent industrial contribution to each plant. (See discussion in Section Three for details of the assignment procedure.) A pass/fail analysis was performed by comparing the three sludge profiles to the maximum allowable pollutant concentrations for sludges disposed of in monofills overlying Class II ground waters. Studies have shown it is highly probable that all existing monofills overlie Class II ground waters.[13] Thus, for purposes of this analysis, all the existing monofills were assumed to be located over Class II ground water.

In the absence of facility-specific data on sludge quality and site characteristics for each facility, it was not feasible to estimate the number of plants that would demonstrate compliance by running a site-specific model. It was thus assumed that all plants failing to meet the criteria would shift to an alternative disposal method.

POTWs could add liners and leachate collection to their monofills to achieve compliance if an EPA-approved model that could account for these controls in calculating maximum allowable pollutant concentrations in sludge were available. EPA sludge models, however, do not currently allow for the inclusion of liners and leachate collection. Additionally, it is not known what pollutant limits would be generated by using this type of model and whether POTWs would be able to meet these new limits. Nevertheless, the costs of adding liners and leachate collection are presented below for comparison with the costs of shifting to alternative disposal methods.

Baseline practices were compared to the proposed requirements to determine incremental cost items associated with the management practices in the proposed regulations. The baseline was established as current state and federal regulations. Proposed Part 258 regulations are considered part of baseline practices for those monofills accepting septage. It is not possible at this time, however, to distinguish which POTWs accept septage and which do not.

4.3.2.3 Results

Pass/Fail Analysis

Table 4-41 shows the pass/fail results of comparing the three sludge profiles representing typical sludges, 90th percentile sludges, and 98th percentile sludges to the maximum allowable sludge concentrations listed in the proposed regulation. Of the POTWs that monofill, 29 are in the typical sludge category, 13 in the 90th percentile category, and 7 in the 98th percentile category. If the model sludge concentration for a particular pollutant exceeds its maximum allowable concentration, a "fail" is registered in the table for that pollutant. All pollutants must pass for the sludge to satisfy the requirements of the regulation. According to the analysis in Table 4-41, none of the POTWs would pass all the pollutant limits for any sludge profile.

4.3.2.4 Compliance Costs

Those facilities that pass the numerical criteria will be subject to the siting and management practice requirements in the proposed regulation. The management practice requirements that are incremental to baseline requirements are the siting criteria and minimum operating procedures, including recordkeeping and reporting requirements. No POTWs pass the monofilling criteria, however. Thus the only compliance costs incurred are those for (1) shifting to alternative disposal practices and (2) monitoring,

TABLE 4-41. PASS/FAIL ANALYSIS FOR MONOFILLS UNDER OPTION 3

POLLUTANT	CONCENTRATIONS IN SLUDGE PROFILES (MG/KG) TYPICAL	90th PERC.	98th PERC.	MAXIMUM SLUDGE CONC. (MG/KG)*	PASS/FAIL TYPICAL	90th PERC.	98th PERC.
ARSENIC	4.359	16.39	36.4	24	PASS	PASS	FAIL
CADMIUM	11.189	101.72	384.6	9.6	FAIL	FAIL	FAIL
LEAD	265.741	821.87	1622.8	530	PASS	FAIL	FAIL
MERCURY	1.735	7.21	17	26	PASS	PASS	PASS
BENZENE	0.336487	3.6598	15.42	0.85	PASS	FAIL	FAIL
BAPYRENE	0.001	0.234	6.911	250	PASS	PASS	PASS
BEHP	104.796	367.158	781.527	1600	PASS	PASS	PASS
DDT/DDE/DDD	0.006713	0.0331443	0.0872404	51	PASS	PASS	PASS
DMN	0.281	0.78	1.445	0.07	FAIL	FAIL	FAIL
LINDANE	0.004865	0.0294687	0.0872404	75	PASS	PASS	PASS
PCB	0.004865	0.0294687	0.0872404	49	PASS	PASS	PASS
TOXAPHENE	0.004865	0.0294687	0.0872404	1.1	PASS	PASS	PASS
TCE	0.529272	20.1945	181.22	51	PASS	PASS	FAIL

*Maximum sludge concentrations are those for monofills located over Class II groundwater.

recordkeeping and reporting, where still applicable in the alternative disposal scenario (e.g., when the alternative chosen is incineration).

Shifts in Disposal Practice

All POTWs now using monofills as a disposal option are assumed to shift to an alternative disposal method because all three sludge profiles are projected to fail the criteria. As discussed in Section 4.2.2, alternative disposal methods are limited. The smallest facilities (those represented by the 0.1-MGD and 0.5-MGD model facilities) are assumed to be able to shift to municipal landfills for disposal. The larger facilities, however, with their potential for significant impact on municipal landfill capacity problems, are assumed to shift to incineration as a means of sludge disposal. Composting with monofilling is not an available option since composted sludge fails to meet the Option 3 criteria for monofilling. Some POTWs could shift to nonagricultural land application, but this is considered unlikely because of practical considerations. For example, odors can be more noticeable when sludge is land applied than when it is buried. Also, since monofilling occurs primarily in Massachusetts and Rhode Island, the land required may be too difficult or too expensive to obtain. Therefore, the costs for shifting sludge disposal to nonagricultural land application were not evaluated.

The baseline costs for codisposal were developed in Section Three, Table 3-31, and range from $290 to $340/DMT for codisposal for the 19 facilities in the 0.5-MGD and 0.1-MGD size classes, respectively. Costs for incineration under Option 3 requirements, which include costs of wet ESPs and afterburners, are developed below.

Baseline costs of incineration were developed in Section Three. Based on these costs, costs for incineration without pollution control requirements for onsite incineration at the 30 facilities in the three largest size classes range from $153 to $772/DMT. Pollution control devices such as wet ESPs and afterburners are assumed to be required to meet the incinerator requirements of Option 3. The retrofit costs have been used to approximate the costs of building incinerators with these devices. The assumption that retrofit costs can be used to approximate costs for constructing these devices in place may overstate costs considerably, however. First, many incinerators may be able to meet both metals and THC requirements by manipulating design parameters at a very small incremental cost. Second, many POTWs may elect to build fluid-bed incinerators, which are less expensive to build and operate than multiple hearth incinerators with afterburners. Third, those POTWs that do elect to construct multiple hearth incinerators with afterburners would also most likely add energy recovery systems. As discussed in Section 4.3.1, adding energy recovery systems is estimated to reduce the annual cost of afterburners by 10 percent. Thus, only 50 percent of the costs of retrofitting wet ESPs and afterburners are considered to be incremental to baseline incineration costs. Wet ESPs and afterburners cost an additional $807/DMT for the 2-MGD size class incinerator, $403/DMT for the 14-MGD size class incinerator and $80/DMT for the 128-MGD size class incinerator. Thus $404, $202, and $40 have been added to the baseline costs of incineration for these size classes.

Total costs of incineration under Option 3 thus range from $193 to $1,176/DMT (see Table 4-42). The incremental costs of shifting disposal practice are also shown in Table 4-42. Total annual incremental costs of shifting disposal practices are $24.5 million.

Monitoring, Recordkeeping and Reporting

All POTWs that are currently monofilling are expected to shift to codisposal or incineration as a result of Option 3 requirements. Those POTWs shifting to codisposal will not be required to monitor their sludge quality, but those shifting to incineration will be required to test for the seven metals that are covered by the incineration rules. The frequency of sludge testing varies by POTW size, with POTWs generating less than 1 MGD wastewater required to test annually, those generating 1 to 10 MGD required to test quarterly and those generating more than 10 MGD required to test monthly. Testing costs for the seven metals total $105 per POTW per testing period.

TABLE 4-42

ANNUAL INCREMENTAL COST OF SHIFTING FROM MONOFILLING TO ALTERNATIVE DISPOSAL METHODS UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS	COST OF MONOFILLING PER DMT	ALTERNATIVE DISPOSAL METHOD	COST OF ALTERNATIVE PER DMT	INCREMENTAL COST PER DMT	TOTAL COST PER FACILITY
0.1 MGD	5	$301	Codisposal	$ 340	$ 39	$ 4,290
0.5 MGD	14	$183	Codisposal	$ 290	$ 107	$ 166,278
2 MGD	19	$245	Incineration	$1,176	$ 931	$ 7,871,605
14 MGD	10	$ 83	Incineration	$ 485	$ 402	$12,526,320
128 MGD	1	$ 55	Incineration	$ 193	$ 138	$ 3,929,964
Total	49					$24,498,457

Source: ERG estimates.

Note: DMT = Dry metric ton.

In addition, the POTWs shifting to incineration will also have to perform continuous monitoring and recording at a cost of $18,070 per facility annually; they will have to undertake performance testing and dispersion modeling, costing $12,831 per facility; and they will have to perform recordkeeping and reporting tasks, which are estimated to cost $525 per facility and $150 per facility per reporting period, respectively. These costs were derived in Section 4.3.1.

Incremental costs for monitoring, recordkeeping and reporting, shown in Table 4-43, total $995,820 in the first year and $610,890 in subsequent years.

Liners and Leachate Collection Systems

The annual cost of installing liners and leachate collection systems was developed for the five model facility sizes as discussed in Section 4.2.2.2. Total liner and leachate collection system costs for each model size were previously shown in Table 4-18. Annualized capital and annual leachate treatment costs range from $10,732 to $1,271,651, depending on facility size. If this were a viable compliance option, the total annual cost of the monofilling provisions would be $6.9 million (see Table 4-44). (Total costs could be somewhat higher than this since costs for methane monitoring and meeting Class B pathogen reduction requirements, where not currently achieved, would also be incurred.)

In the two smallest size classes, it would be less expensive to shift to codisposal than to install liners and leachate collection systems. The larger facilities, however, would find installing liners and leachate collection systems more economical than shifting to incineration. If the largest facilities installed liners and leachate collection systems in lieu of shifting to incineration and the smallest shifted to codisposal, the incremental cost of the regulation could be as low as $6.4 million (not including the management practice costs noted above - see Table 4-45).

TABLE 4-43

ANNUAL SEWAGE SLUDGE MONITORING, RECORDING, AND RECORDKEEPING COSTS FOR POTWS SHIFTING FROM MONOFILLING TO INCINERATION UNDER OPTION 3 ($1987)

SIZE	NO. OF POTWS SHIFTING TO INCIN- ERATION	FREQUENCY OF MONITORING AND REPORTING	SLUDGE TESTING COSTS/ YEAR	CONTINUOUS MONITORING AND RECORD- ING COSTS	PERFORMANCE TESTING AND DISPERSION MODELING	RECORD- KEEPING COSTS	REPORTING COSTS	TOTAL ANNUAL INCREMENTAL COST OF MONITORING, RECORD- KEEPING, AND REPORTING[a]
0.1 MGD	0	1/yr	0	0	0	0	0	0
0.5 MGD	0	1/yr	0	0	0	0	0	0
2 MGD	19	4/yr	7,980	343,330	243,789	9,975	11,400	616,474
14 MGD	10	1/mo	12,600	180,700	128,310	5,250	18,000	344,860
128 MGD	1	1/mo	1,260	18,070	12,831	525	1,800	34,486
Total	30		21,840	542,100	384,930	15,750	31,200	995,820

[a] First-year costs. Costs in subsequent years are $610,890.

Source: ERG estimates.

TABLE 4-44

TOTAL ANNUAL COST OF COMPLIANCE FOR ADDITION OF LINERS AND LEACHATE COLLECTION (L&LC) UNDER OPTION 3

($1987)

SIZE	NUMBER OF POTWS	INCREMENTAL COST OF L&LC PER FACILITY	TOTAL INCREMENTAL COST OF L&LC FOR ALL FACILITIES	MONITORING, RECORD-KEEPING & REPORTING COST PER FACILITY[a]	MONITORING, RECORDING AND REPORTING COST FOR ALL FACILITIES	TOTAL COMPLIANCE COSTS
0.1 MGD	5	$ 10,732	$ 53,660	$1,533	$ 7,665	$ 61,325
0.5 MGD	14	42,354	592,956	1,533	21,462	614,418
2 MGD	19	146,552	2,784,488	4,557	86,583	2,871,071
14 MGD	10	195,409	1,954,090	12,621	126,210	2,080,300
128 MGD	1	1,271,651	1,271,651	12,621	12,621	1,284,272
TOTAL	49		6,656,845		254,541	$6,911,386

Note: Testing costs are based on a cost of $15/metal for four metals and $698 for all organics. Additionally, pathogen testing is assumed to cost $100/test and vector attraction testing is assumed to have a negligible cost. These assumptions are discussed in more detail in Section 4.3.4. POTWs processing under 1 MGD are required to test once per year; POTWs processing 1 to 10 MGD must test quarterly; and POTWs processing over 10 MGD must test monthly. All testing costs are assumed incremental since existing state regulations do not specify testing parameters. Recordkeeping and reporting costs are assumed similar to those for incineration - $525/POTW and $150/POTW/reporting period, respectively.

[a] Does not include costs for methane monitoring or meeting Class B pathogen reduction requirements not currently achieved.

Source: ERG estimates.

TABLE 4-45

TOTAL ANNUAL COST OF COMPLIANCE FOR POTWS USING LINERS AND LEACHATE COLLECTION (L&LC) OR CODISPOSAL UNDER OPTION 3

($1987)

SIZE	NUMBER OF POTWS	INCREMENTAL COST OF L&LC OR CODISPOSAL COST OF L&LC PER FACILITY	TOTAL INCREMENTAL COST OF L&LC AND CODISPOSAL FOR ALL FACILITIES	MONITORING, RECORDKEEPING AND REPORTING COST PER FACILITY	TOTAL MONITORING, RECORDKEEPING AND REPORTING COST FOR ALL FACILITIES	TOTAL COMPLIANCE COSTS[a]
0.1 MGD	5	$ 858	$ 4,290	$ 0	$	$ 4,290
0.5 MGD	14	11,877	166,278	0	0	166,278
2 MGD	19	146,552	2,784,488	4,557	86,583	2,871,071
14 MGD	10	195,409	1,954,090	12,621	126,210	2,080,300
128 MGD	1	1,271,651	1,271,651	12,621	12,621	1,284,272
TOTAL	49		$6,180,797		$147,514	$6,406,211

[a] Does not include costs for methane monitoring, or meeting Class B pathogen reduction requirements, where not currently achieved.

Source: ERG estimates.

Total Compliance Costs

Total first-years costs associated with shifting disposal methods, including sludge monitoring, record keeping and reporting are $25.5 million (see Table 4-46). Costs in subsequent years are $25.1 million.

Approximately 1.8 million residents are served by POTWs using sludge monofills. Assuming that POTWs meet the regulatory requirements exclusively by shifting to alternative disposal methods and assuming three residents per household, total annual incremental costs associated with the proposed monofill regulations are $42.86 per household in the first year and $42.21 per household in subsequent years. Actual costs per household would be somewhat lower than this because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned. If the largest POTWs could install liners and leachate collection systems rather than switch to incineration, the cost per household would drop by about $30 to a total of $10.77 per household.

4.3.3 Costs and Impacts of Regulatory Option 3 Governing the Land Application of Sewage Sludge

This section describes the regulations regarding the land application of sewage sludge and provides estimates of the associated compliance costs.

4.3.3.1 Overview of the Proposed Regulations

The requirements of the proposed regulations for land application encompass pollutant-specific numeric criteria and management practice requirements. These criteria and management practices vary for agricultural and nonagricultural lands. Additionally, all POTWs practicing land application, regardless of sludge end use, must monitor their sludge quality for pollutants, pathogens and vector attraction parameters, and must perform recordkeeping and reporting tasks. Recordkeeping tasks include the maintenance of contracts with the end users of the sludge. These contracts

TABLE 4-46

TOTAL ANNUAL INCREMENTAL COSTS OF COMPLIANCE FOR POTWS USING MONOFILLS UNDER OPTION 3

($1987)

SIZE	MONITORING, RECORDKEEPING, AND RECORDING COSTS	SHIFTING COSTS	TOTAL COSTS[a]
0.1 MGD	$ 0	$ 4,290	$ 4,290
0.5 MGD	0	166,278	166,278
2 MGD	616,474	7,871,605	8,488,079
14 MGD	344,860	12,526,320	12,871,180
128 MGD	34,486	3,929,964	3,964,450
Total	$995,820	$24,498,457	$25,494,277

[a] These are first-year costs. Costs in subsequent years would be $25,109,347.

Source: ERG estimates.

specify the conditions that must be met by the end users to ensure that the management requirements for land application are met. As is the case for the other disposal methods, those POTWs processing less than 1 MGD must prepare reports and test their sludge annually. Those processing more than 1 and less than 10 MGD must prepare reports and test quarterly, and those processing more than 10 MGD must prepare reports and test monthly.

Agricultural Land Application Requirements

Agricultural land is defined as land on which crops are grown for either direct or indirect human consumption or for animal feed. In addition to food crops, this category includes land on which feed crops for animals are grown and land used as pasture for grazing animals.

The regulatory criteria for sewage sludge applied to agricultural land do not directly limit pollutant concentrations in the sludge itself; the criteria limit the application rate (the maximum amount of sludge that can be applied at one time to a unit area of land) and the pollutant loading rate (the maximum amount of a pollutant that can be applied to a unit area of land either during a calendar year or cumulatively). Fifteen organic pollutants are covered by annual pollutant loading rate restrictions; ten inorganic pollutants are covered by cumulative pollutant loading rate limits.

The management practice requirements for agricultural land application vary depending on the level of pathogen reduction achieved during and following the sludge treatment process. The Class A pathogen reduction is the highest level of control (i.e., most stringent), Class B is a lesser level of control than Class A, and Class C is the lowest level of control. POTWs are only required to meet a minimum of Class C pathogen reduction requirements; those POTWs that achieve Class A or B pathogen reductions are subject to lesser restrictions on access to and use of lands on which the sludge has been applied.

The pathogen reduction requirements that define Class A, B, and C sludge are similar to existing regulations (40 CFR Part 257) defining levels of pathogen and vector attraction reduction. The existing regulations define Processes to Significantly Reduce Pathogens (PSRP) and Processes to Further Reduce Pathogens (PFRP). Class B pathogen reduction corresponds approximately with PSRP; PFRP corresponds approximately to Class A pathogen reduction; Class C requirements are less stringent than PSRP. Table 4-47 presents a comparison of the pathogen reduction classes in the proposed regulations to those in the existing regulations.

The land use and access restrictions for each class of sludge are summarized in Table 4-48. For Class C sludges, food crops cannot be grown for 18 months on land where sewage sludge has been applied. Root crops cannot be grown on this land for 5 years. Feed crops cannot be harvested and animals cannot graze on this land for 60 days after the application. Public access to the site must be restricted for 12 months. Class B sludge must meet the same requirements as Class C except that feed crops can be harvested after 30 days and animals are allowed to graze after 30 days. There are no restrictions on the use of land that has received Class A sludge.

Nonagricultural Land Application Requirements

Nonagricultural land is defined as land that is not used for pasture and as land on which neither food nor feed crops are grown. This includes, but is not limited to, forest land (silviculture), reclaimed land, and dedicated land. Maximum sewage sludge pollutant concentrations are defined for 12 organic and 10 inorganic pollutants for this type of land application. No application rates, either maximum annual or cumulative, are defined for this end use.

The management practices that must be followed for nonagricultural land application include prohibitions against using the land for food, for feed crops, or for grazing animals. Where Class A sludge is applied, public access must be restricted until a vegetative cover is established. When either Class B or Class C sludge is applied to nonagricultural land, public access must be restricted for 1 year.

TABLE 4-47

COMPARISON OF EXISTING AND PROPOSED REGULATIONS FOR CONTROL OF PATHOGENS

NEW REGULATIONS	EXISTING REGULATIONS
Class C Pathogen and Vector Attraction Reduction • Standards for pathogen reduction requirements less stringent than PSRP. • Regulations for vector attraction and pathogen reduction are separated. • Pathogen reduction requirements are less than those for Class A or Class B, but with the use of comparable health safety access restriction requirements, standards are maintained. • Pathogen reduction requirements defined in quantitative terms that can be met using a combination of processing steps.	PSRP: Process to Significantly Reduce Pathogens • Reduction of vector attractions and pathogen reduction are tied together. • Only one stabilization process can be employed to achieve PSRP. • Pathogen reduction requirements are not defined in quantitative terms. • No controls on grazing of non-food-chain animals or the harvesting of crops.
Class B Pathogen and Vector Attraction Reduction • Standards for pathogen reduction similar to PSRP. • Pathogen reduction requirements defined in quantitative terms that can be met using a combination of processing steps. • Regulations for vector attraction and pathogen reduction are separated.	PFRP: Process to Further Reduce Pathogens • Reduction of vector attraction and pathogen reduction are tied together. • Only one stabilization process can be employed to achieve PFRP. • Pathogen reduction requirements are not defined in quantitative terms. • Specific process (e.g., composting, heat treatment) are specified to fulfill requirements.
Class A Pathogen and Vector Attraction Reduction • Standards for pathogen reduction similar to PFRP. • Pathogen reduction requirements defined in quantitative terms that can be met using a combination of processing steps. • Regulations for vector attraction and pathogen reduction are separated.	

Source: ERG Analysis; U.S. EPA, 1987. Technical Suport Document for Pathogens in Sewage Sludge, Office of Water.

TABLE 4-48

COMPARISONS OF ACCESS AND USE RESTRICTIONS ASSOCIATED WITH PATHOGEN CONTROL LEVELS

	CURRENT REGULATION	PROPOSED REGULATION		
RESTRICTIONS	PSRP	CLASS C	CLASS B	CLASS A
Period of controlled public access.	12 mo.	12 mo.	12 mo.	0 mo.
Time lapse required before crops for direct human consumption (DHC) are grown.	18 mo.	18 mo.	18 mo.	0 mo.
Time lapse before DHC root crops are grown if sludge is injected underground.	18 mo.	5 yrs.	5 yrs.	0 yrs.
Time lapse before grazing of animals whose products are consumed by humans.	1 mo.	60 days	30 days	0 days
Time lapse before grazing of animals whose products are not consumed by humans.	--	60 days	30 days	0 days
Time lapse before harvesting of of feed crops.	--	60 days	30 days	0 mo.

Source: U.S. EPA, 1987. Technical Support Document for Pathogens in Sewage Sludge, Office of Water.

2052S

4.3.3.2 Methodology

The costs of compliance were developed using a two-stage process. First, a pass/fail analysis was performed. The numeric criteria for both agricultural and nonagricultural land application were compared to the three sludge quality profiles defined in Section Three. The results of this pass/fail analysis reflect the number of facilities that would be in compliance with the proposed criteria. Additionally, for the plants using land application on agricultural land, the number of applications of sludge that could be made to each unit of land was determined. For agricultural land application, it was assumed that the cumulative application rate requirements were met if the sludge could be applied at least once in compliance with the criteria.

To determine whether sludges applied to agricultural land could comply with the pollutant loading restrictions, it was assumed that each sludge type was applied at a loading rate of 11 dry metric tons per hectare, a typical sludge application rate.[14] The loading rate of each contaminant was calculated based on the sludge application rate and the contaminant concentration levels in the sludge. Loading rates were calculated for each of the three representative sludges. The calculated loading rates were compared to the maximum loading rates specified in the proposed regulation. For the sludge to pass, calculated rates must be lower than maximum allowable rates for all pollutants.

For nonagricultural end uses, maximum allowable pollutant concentrations for the sludge are specified in the proposed regulation; no maximum application rates must be met. These requirements were evaluated by comparing maximum allowable pollutant concentrations to the pollutant concentrations of the three sludge profiles.

Nonagricultural land appliers that could not meet the maximum pollutant concentrations and agricultural land appliers that could not meet either annual or cumulative application rate requirements were assumed to shift to the lowest cost available disposal method.

Second, the incremental actions associated with complying with the management practices were established and the associated costs were developed. The baseline for determining incremental actions was current state and federal regulations. Incremental costs were based on actual costs of material and labor needed to comply with the proposed management practices.

4.3.3.3 Results

The criteria for agricultural land application are different from those for nonagricultural land application. Thus, the pass/fail analysis discusses these two land application types separately.

Agricultural Land Application

The results of the pass/fail analysis for agricultural land application are presented in Table 4-49. This table shows that at a whole sludge application rate for typical sludges of 11 DMT/hectare, compliance with all of the annual and cumulative application limits for agricultural land application would be achieved. Any application of typical sludge at rates up to 23 DMT/hectare would also achieve compliance. The 90th and 98th percentile sludges do not pass at the typical application rates.

One method of attaining compliance with the criteria would be to reduce the sludge application rate for the 90th and 98th percentile sludges. The sludge application rates assumed in the analysis were chosen to represent typical conditions. In practice, a wide range of application rates are used; 2 DMT/ha to 70 DMT/ha have been reported (see Note 14). A small reduction in application rate can probably be accommodated in most situations. A drastic reduction, however, may change circumstances enough that disposal practices must be altered. Sludge application rates for the 90th and 98th percentile sludges would have to be reduced below 1 DMT per hectare to meet the criteria. Application rates this low are considered practically infeasible.

TABLE 4-49. PASS/FAIL ANALYSIS FOR AGRICULTURAL LAND APPLICATION UNDER OPTION 3

	POLLUTANT CONCENTRATION			MAX APPL	METRIC TONS PER HA			ANNUAL POLLUTANT LOADING PASS/FAIL			CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATION		
					11	11	11						
Pollu- tant	TYPICAL (MG/KG)	90th PERC. (MG/KG)	98th PERC. (MG/KG)	RATE (KG/HA)	TYPICAL (kg/ha)	90th PERC. (kg/ha)	98 PERC. (kg/ha)	TYPICAL	90th PERC.	98th PERC.	TYPICAL	90th PERC.	98th PERC.
As	4.359	16.39	36.4	14	0.047949	0.18029	0.4004	NA	NA	NA	292.0	77.7	35.0
Cd	11.189	101.72	384.6	17	0.123079	1.11892	4.2306	NA	NA	NA	138.1	15.2	4.0
Cr	248.164	1190.64	3063	200	2.729804	13.09704	33.693	NA	NA	NA	73.3	15.3	5.9
Cu	411	1507.94	3300.3	46	4.521	16.58734	36.3033	NA	NA	NA	10.2	2.8	1.3
Pb	265.741	821.87	1622.8	77	2.923151	9.04057	17.8508	NA	NA	NA	26.3	8.5	4.3
Hg	1.735	7.21	17	11	0.019085	0.07931	0.187	NA	NA	NA	576.4	138.7	58.8
Mo	13.217	78.4	229.2	1.71	0.145387	0.8624	2.5212	NA	NA	NA	11.8	2.0	0.7
Ni	70.114	365.39	988	78	0.771254	4.01929	10.868	NA	NA	NA	101.1	19.4	7.2
Se	1.446	9.06	27.4	25	0.015906	0.09966	0.3014	NA	NA	NA	1,571.7	250.9	82.9
Zn	979.834	3806.37	8622.4	170	10.778174	41.87007	94.8464	NA	NA	NA	15.8	4.1	1.8
A/D	0.0048651	0.0294687	0.0872404	0.016	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
BAP	0.001	0.234	6.911	0.13	0.000011	0.002574	0.076021	PASS	PASS	PASS			
CLD	0.0048651	0.0294687	0.0872404	1.2	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DDT	0.0067135	0.0331443	0.0872404	0.0055	0.0000738	0.000364587	0.000959644	PASS	PASS	PASS			
HEPC	0.0048651	0.0294687	0.0872404	0.073	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
HXBE	0.04	0.563	2.753	0.039	0.00044	0.006193	0.030283	PASS	PASS	PASS			
HXBU	0.112	0.312	0.578	0.334	0.001232	0.003432	0.006358	PASS	PASS	PASS			
LIN	0.0048651	0.0294687	0.0872404	4.6	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
PCB	0.0048651	0.0294687	0.0872404	0.0056	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
TOX	0.0048651	0.0294687	0.0872404	0.048	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DMN	0.281	0.78	1.445	0.039	0.003091	0.00858	0.015895	PASS	PASS	PASS			
TCE	0.529272	20.1945	181.22	0.013	0.0058219	0.2221395	1.99342	PASS	FAIL	FAIL			

Source: ERG estimates.

The cumulative limit (based on inorganic pollutants) for typical sludge at the 11 tons/hectare application rate is 10 applications. Copper is the limiting factor in typical sewage sludge since the lowest number of applications was calculated for this pollutant among all the regulated pollutants using the cumulative pollutant loading limits. For the 90th percentile sludge the cumulative pollutant loading limits allow 2 years of applications. The cumulative pollutant limits are exceeded with one application of 98th percentile sludge at typical rates. Thus even if annual criteria are met by the 98th percentile sludges, these sludges cannot be land applied in compliance with the proposed regulation.

POTWs using agricultural land application whose sludges do not pass the criteria are assumed to shift to nonagricultural land application or to a different disposal option. POTWs with sludges that do pass must adhere to the relevant management practices. The incremental costs associated with shifting disposal options and complying with management practices are discussed below in Section 4.3.3.5.

Nonagricultural Land Application

The results of the pass/fail analysis for nonagricultural land application are presented in Table 4-50. As the table shows, both typical and 90th percentile sludges pass the concentration limits, while 98th percentile sludges fail for several pollutants. The failure of 98th percentile sludges is expected, since the criteria have been defined such that only 98th percentile sludges fail (as was done under Option 2 for all disposal methods). Those POTWs whose sludges exceed the maximum pollutant concentrations are assumed to shift to a different disposal option. Those whose sludges meet the criteria must also meet the management practice requirements of the proposed regulation. The costs for shifting to alternative disposal methods and for complying with required management practices are discussed in Section 4.3.3.5.

TABLE 4-50. PASS/FAIL ANALYSIS FOR NONAGRICULTURAL LAND APPLICATION UNDER OPTION 3

	POLLUTANT CONCENTRATION			MAX	PASS/FAIL		
Pollutant	TYPICAL (MG/KG)	90th PERC. (MG/KG)	98th PERC. (MG/KG)	SLUDGE CONC (MG/KG)	TYPICAL	90th PERC.	98th PERC.
As	4.359	16.39	36.4	36	PASS	PASS	FAIL
Cd	11.189	101.72	384.6	380	PASS	PASS	FAIL
Cr	248.164	1190.64	3063	3100	PASS	PASS	PASS
Cu	411	1507.94	3300.3	3300	PASS	PASS	FAIL
Pb	265.741	821.87	1622.8	1600	PASS	PASS	FAIL
Hg	1.735	7.21	17	17	PASS	PASS	FAIL
Mo	13.217	78.4	229.2	230	PASS	PASS	PASS
Ni	70.114	365.39	988	990	PASS	PASS	PASS
Se	1.446	9.06	27.4	27	PASS	PASS	FAIL
Zn	979.834	3806.37	8622.4	8600	PASS	PASS	FAIL
A/D	0.0048651	0.0294687	0.0872404	0.33	PASS	PASS	PASS
BAP	0.001	0.234	6.911	6.9	PASS	PASS	FAIL
CLD	0.0048651	0.0294687	0.0872404	24	PASS	PASS	PASS
DDT	0.0067135	0.0331443	0.0872404	0.11	PASS	PASS	PASS
HEPC	0.0048651	0.0294687	0.0872404	1.5	PASS	PASS	PASS
HXBE	0.04	0.563	2.753	2.8	PASS	PASS	PASS
HXBU	0.112	0.312	0.578	6.8	PASS	PASS	PASS
LIN	0.0048651	0.0294687	0.0872404	92	PASS	PASS	PASS
PCB	0.0048651	0.0294687	0.0872404	0.11	PASS	PASS	PASS
TOX	0.0048651	0.0294687	0.0872404	0.97	PASS	PASS	PASS
DMN	0.281	0.78	1.445	1.4	PASS	PASS	FAIL
TCE	0.529272	20.1945	181.22	180	PASS	PASS	FAIL

4.3.3.4 Numbers of POTWs Failing to Meet Land Application Criteria by End Use

There are several categories of sludge end uses. Agricultural end uses, especially feed crops, account for the majority of the sludge applied to land. This end use is employed by 77 percent of the land-applying POTWs (see discussion in Section 4.2.2). Sludge applied to dedicated land or used for reclamation (the end uses accounting for 10 percent of land-applied sludge) is considered nonagricultural land application. A third group of land-applied sludge includes such end uses as sod farms, nurseries, golf courses, etc. This group constitutes 13 percent of all land applied sludges. These "other" end uses are primarily considered to be nonagricultural. The three nonagricultural land application end uses - dedicated disposal, land reclamation, and other - are discussed separately since the baseline costs of each of these methods differ.

Table 4-51 presents the breakdown of the numbers of POTWs generating each type of sludge in each of the four major end uses (agriculture, dedicated disposal, reclamation and other). Note that silviculture, the application of sludge to forest land, is currently an experimental practice. No POTWs have been assigned to this end use.

The numbers of affected POTWs (those generating 90th and 98th percentile sludges going to agricultural end uses and those generating 98th percentile sludges going to nonagricultural end uses) have been estimated based on the total numbers of POTWs generating affected sludge types and the distributions noted above for each end use. As Table 4-51 shows, 266 POTWs practicing agricultural land application will fail to meet the land application criteria (the 224 POTWs estimated to generate 90th percentile sludge and the 42 POTWs estimated to generate 98th percentile sludges). Only 12 POTWs practicing nonagricultural land application will fail (3 POTWs practicing dedicated disposal, 2 practicing reclamation and 7 practicing "other" land application in the 98th percentile sludge category).

TABLE 4-51

DISTRIBUTION OF POTWs BY SLUDGE TYPE AND END USE

					NONAGRICULTURAL													
	AGRICULTURAL				DEDICATED				RECLAMATION				OTHER					
SIZE	TYPICAL	90th[a]	98TH[a]	SUB-TOTAL	TYPICAL	90TH	98TH[a]	SUB-TOTAL	TYPICAL	90TH	98TH[a]	SUB-TOTAL	TYPICAL	90TH	98TH[a]	SUB-TOTAL	TOTAL NON-AGRI-CULTURAL	TOTAL LAND APPLI-CATION
0.1 MGD	791	29	4	824	72	3	0	75	31	1	0	32	134	5	1	140	247	1,071
0.5 MGD	603	65	16	684	55	6	1	62	23	3	1	27	102	11	3	116	205	889
2 MGD	325	111	19	455	29	10	2	41	13	4	1	18	55	19	3	77	136	591
14 MGD	32	16	3	51	3	1	0	4	1	1	0	2	5	3	0	8	14	65
128 MGD	3	3	0	6	0	0	0	0	0	0	0	0	1	0	0	1	1	7
TOTAL	1,754	224	42	2,020	159	20	3	182	68	9	2	79	297	38	7	342	603	2,623

[a] These POTWs are estimated to fail the relevant land application criteria.

Source: ERG estimates.

2106S

4.3.3.5 Compliance Costs

The compliance costs for land-applied sludge include the costs of shifting to alternative disposal practices and the costs of implementing incremental management practice requirements. The costs of each of these components are addressed below.

Shifts in Disposal Practice

Shifts in disposal practice are discussed separately for agricultural land application and nonagricultural land application. The "other" land application category is predominantly nonagricultural; thus, this category will be discussed under the nonagricultural land application section.

Agricultural Land Application. The application rates derived for the 90th and 98th percentile sludges were determined to be impractically low. Thus, all POTWs generating sludge of this quality and using agricultural land application are assumed to shift to alternative disposal methods.

The 224 POTWs generating 90th percentile sludges going to agricultural end uses are assumed to be able to shift to nonagricultural end uses. Agricultural land application is likely to be associated with the availability of open land near the POTW, unlike monofills, which are primarily found in the urbanized states of Massachusetts and Rhode Island. It is thus assumed that POTWs either have or will be able to purchase land for dedicated disposal at a reasonable cost. The annual incremental costs of shifting from agricultural land application to dedicated disposal for POTWs generating 90th percentile sludges are shown in Table 4-52. Total costs of this shift are $2.1 million.

The 42 POTWs generating 98th percentile sludges going to agricultural end uses cannot shift directly to nonagricultural end uses, since they fail the criteria for nonagricultural land application as well. These POTWs are instead assumed to shift to codisposal; composting and dedicated land application (contaminants are diluted during the composting process, allowing

TABLE 4-52

ANNUAL INCREMENTAL COSTS OF SHIFTING 90TH PERCENTILE SLUDGES FROM AGRICULTURAL END USES TO NONAGRICULTURAL END USE (DEDICATED DISPOSAL) UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS	INCREMENTAL COST/DMT	TOTAL COST
0.1 MGD	29	$41	$ 26,158
0.5 MGD	65	17	122,655
2 MGD	111	29	1,432,455
14 MGD	16	11	548,416
128 MGD	3	0	0
Total	224		$2,129,684

Source: ERG estimates.

the sludge to meet the 98th percentile criteria); or incineration, depending on the cost effectiveness of each alternative and the availability of the disposal method for POTWs in each size class. As discussed for other disposal methods, only the smallest POTWs (0.1 and 0.5 MGD) are expected to be able to shift to codisposal. Sludge disposal by larger POTWs in municipal landfills is estimated to have a significant impact on the landfill capacity problems described in Section Three. Table 4-53 shows the incremental costs of shifting 98th percentile sludges from agricultural end uses to codisposal, composting and land application, and incineration. Total annual incremental costs of these shifts are $4.8 million.

Nonagricultural Land Application. The only POTWs that fail to meet the criteria for nonagricultural land application are those POTWs generating 98th percentile sludges, based on how the criteria for this end use have been defined. The most cost-effective disposal alternatives for these POTWs are codisposal for the six POTWs in the smallest two size classes (one POTW practicing reclamation is estimated not to be able to use codisposal, but is expected to shift to composting with land application) and composting prior to land application for the six POTWs in the 2-MGD and 14-MGD size classes (since composting dilutes sludge concentrations below the maximum allowable levels). There are no POTWs currently practicing nonagricultural land application in the largest size class. The incremental costs of shifting disposal practices vary among the types of nonagricultural land application (dedicated disposal, land reclamation, and "other"). The baseline costs of these disposal methods (with the exception of "other") are presented in Section Three. The baseline cost for disposal in the "other" category is estimated to be negligible, since the POTW is assumed to provide the sludge to the end user who then applies the sludge him/herself (i.e., the POTW does not directly or indirectly incur the cost of applying the sludge). Table 4-54 shows the incremental costs of shifting 98th percentile sludges from these nonagricultural end uses to the disposal methods discussed above. The total annual incremental cost for this group of POTWs is $1.0 million.

The incremental costs of using alternative disposal methods compared to the baseline land application costs are considered compliance costs for those

TABLE 4-53

ANNUAL INCREMENTAL COSTS OF SHIFTING 98TH PERCENTILE SLUDGES FROM AGRICULTURAL END USES UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS	DISPOSAL METHOD	INCREMENTAL COST/DMT[a]	TOTAL COST
0.1 MGD	4	Codisposal	$102	$ 8,976
0.5 MGD	16	Codisposal	111	197,136
2 MGD	19	Composting and dedicated land application[a]	355	3,001,525
14 MGD	3	Composting and dedicated land application[a]	174	1,626,552
128 MGD	0	Composting and dedicated land application	189	0
TOTAL	42			$4,834,189

[a] The incremental cost/DMT includes the cost for composting the sludge as well as the difference in cost between agricultural land application and dedicated land application.

Source: ERG estimates.

2054S

TABLE 4-54

ANNUAL INCREMENTAL COST OF SHIFTING 98TH PERCENTILE SLUDGES FROM NONAGRICULTURAL END USES UNDER OPTION 3
($1987)

SIZE	ALTER-NATIVE DISPOSAL METHOD	DEDICATED DISPOSAL			RECLAMATION			OTHER			GRAND TOTAL
		NO. OF POTWS	INCREMENTAL COST/DMT	TOTAL	NO. OF POTWS	INCREMENTAL COST/DMT	TOTAL	NO. OF POTWS	INCREMENTAL COST/DMT	TOTAL	
0.1 MGD	Codisposal	0	$ 61	$ 0	0	$813	$ 0	1	$ 340	$ 7,480	$ 7,480
0.5 MGD	Codisposal	1	94	10,434	1[a]	458[a]	50,838[a]	3	290	96,570	157,842
2 MGD	Composting and land application[b]	2	326	290,140	1	326	145,070	3	326	435,210	870,420
14 MGD	Composting and land application[b]	0	163	0	0	163	0	0	163	0	0
128 MGD	Composting and land application	0	189	0	0	72	0	0	147	0	0
TOTAL		3		$300,574	2		$195,908	7		$539,260	$1,035,742

[a] Since land reclamation is a very expensive option, it is assumed that POTWs practicing this method do not have a cheaper option such as codisposal available to them. Therefore, the POTW is assumed to shift to composting its sludge prior to reclamation to meet the criteria for land application. The incremental cost shown is for composting only.

[b] The incremental cost/DMT is for composting only. The same nonagricultural end use is assumed to be available to these POTWs following composting as before.

[c] POTWs in this size class would choose incineration in lieu of composting if now using reclamation.

Source: ERG estimates.

2055S

POTWs that shift practices. The incremental costs of incineration include the costs of complying with the proposed incineration criteria as derived in previous sections of the Option 3 analysis.

Costs of Management Practices

Total management practice costs comprise costs for pathogen and disease vector attraction reductions, access and use restrictions, application rate reductions and sludge testing. Each of these practices is discussed below.

Pathogen Reduction. Class B pathogen reductions are similar to those achieved using PSRP, which is required under existing regulations. Since Class C pathogen reduction is the minimum pathogen reduction requirement, and since it is less stringent than PSRP, no additional costs are assumed to be incurred to meet pathogen reduction requirements.

Vector Attraction Reduction. A choice of vector attraction reduction methods may be applied. One choice is less restrictive than current PSRP requirements; one is slightly more restrictive; the others are not directly comparable. It is assumed that no incremental costs are associated with meeting new vector attraction reduction requirements.

Access and Use Restrictions. The access and use restrictions for land application include waiting periods before harvesting or grazing, access restrictions, and buffer zones to surface water. These requirements are operational activities that must be adhered to, but whose incremental costs are not easily estimated. Many of these operating procedures are specified in 40 CFR Part 257, in current EPA guidance documents regarding land application of sewage sludge, and in current state requirements. No compliance costs were estimated for these actions.

Application Rate Reductions. The typical application rate on agricultural land of 11 DMT/ha allows typical sludges to pass the annual application rate requirements for agricultural land application. Additionally, up to 10 applications of typical sludge on the same site may be performed at this application rate. Therefore, no major changes in practices are estimated for sludges that can continue to be applied to agricultural land, and no incremental costs associated with changes in application rates or in numbers of applications are incurred.

Monitoring, Recordkeeping and Reporting. The general-practice mandates for both agricultural and nonagricultural land application require sludge quality monitoring of pollutants, pathogens and vector attraction parameters. The frequency of monitoring is based on the size of the POTW: yearly for POTWs processing less than 1 MGD; quarterly for POTWs processing 1 to 10 MGD; and monthly for POTWs processing more than 10 MGD. As discussed in Section 4.2.2.2, it is assumed that all the costs of sludge monitoring are incremental to baseline costs. This assumption was made since few states require testing of the same parameters or at the frequency required to comply with the proposed regulation. This assumption somewhat overstates the incremental costs of sludge testing, but this overestimation is not believed to be significant. The actual baseline costs for testing in most states primarily include only the costs of testing metals at a fairly low frequency per year.

Incremental costs of sludge monitoring were calculated as follows. Inquiries to several testing laboratories resulted in the following average costs for testing sludge for pollutants: $15 per metal and $698 for the entire set of organic chemicals covered by the proposed regulation for sludges that are not composted. Pollutant analysis costs for composted sludges are slightly higher: $18 per metal and $823 for tests on all organics. A few POTWs are estimated to shift to composting with land application, so will incur slightly higher sludge costs for pollutant analysis. Pathogen testing costs are estimated at $100 per test, and costs of vector attraction tests are estimated to be negligible. Many POTWs already perform three of the four vector attraction tests on a routine basis and only one of the four tests is required to be chosen. Additionally, all are relatively simple tests to perform.

Recordkeeping and reporting tasks must also be performed under Option 3. Contracts will have to be issued by any POTW that does not directly control the application of the sludge. It is assumed that only POTWs in the "other" category do not now either have a contract or dispose of the sludge themselves. This assumption was made because baseline disposal costs were developed assuming that POTWs perform all land application except "other" land application themselves. The baseline costs of "other" land application were assumed negligible, since it was assumed that the sludge was applied by the recipient of the sludge. It is assumed that the POTWs in the "other" category do not apply the sludge themselves or do not have a contractor apply the sludge. These POTWs are thus estimated to be required to write contracts. Examples of contracts are widely available, and a generic contract in which the specific information required can be filled in is all that is assumed to be necessary. The costs of implementing a contract system primarily includes only labor costs for the assistant superintendent and clerical staff to prepare, reproduce, and file these contracts. Sixteen hours of the superintendent's and four hours of a clerical staff person's hours were assumed to be needed annually. Hourly labor rates are $14.42 and $10.49 respectively. In addition, copy charges for 500 one-page contracts at $0.10 per page were allotted. The total annual cost per POTW is $324.

It is estimated that a total of 338 POTWs will need to establish contractual control over their sewage sludge disposal (the total number of POTWs practicing "other" land application is 342. Of these POTWs, four POTWs generating 98th percentile sludges are estimated to shift to codisposal rather than to continue to land apply). Thus a cost of $109,512 is estimated as the total cost of contractural control for all POTWs with sludge going to "other" end uses. This figure does not include the POTWs that generate 98th percentile sludges going to "other" end uses that are shifted to codisposal (see discussion below under "Shifts in Disposal Practices.")

Other recordkeeping tasks, which include sludge test results, certifications of access and use restrictions, amounts of sewage sludge applied, and the amounts of organic and inorganic pollutants applied at each site, among others, are expected to entail 1 hour per week at clerical wages of $10.49 for a total of $525 per POTW annually. Reporting costs vary by the frequency of the reporting period. As for testing, reporting is required once per year for POTWs processing less than 1 MGD, 4 times per year for POTWs processing 1 to 10 MGD and monthly for POTWs processing over 10 MGD. It is assumed that 2 hours of supervisory time per reporting period at $14.46 per hour and 10 hours of clerical time per reporting period at $10.49 per hour will be needed, along with $20 ($0.10 per page for 200 pages) in copying charges for a total of about $150 per POTW per reporting period.

Table 4-55 shows the costs for monitoring, recordkeeping, and reporting. Total costs for these management practice requirements are $7.2 million annually.

Summary of Compliance Costs

Table 4-56 summarizes the estimated compliance costs associated with sludge monitoring, recordkeeping and reporting, and shifts in disposal practices. The total annual incremental costs for POTWs using land application are $15.2 million.

Total residents served by POTWs using land application number 29.2 million. Assuming three persons per household, total incremental costs can be expressed on a per-household basis: $1.56 per household per year for POTWs using agricultural and nonagricultural land application. In addition to the residential population, commercial and industrial customers are also part of the total population served. The incremental costs, therefore, would be spread over all customers and the actual per-household increment would be reduced.

4.3.4 Costs and Impacts of Regulatory Option 3 Governing the Distribution and Marketing of Sewage Sludge

As noted in Section Three, POTWs were classified as practicing distribution and marketing if they used composting to prepare their sludge for

TABLE 4-55

ANNUAL MONITORING, RECORDKEEPING, AND REPORTING COSTS FOR POTWS PRACTICING LAND APPLICATION

($1987)

	NO. OF POTWs									
SIZE	NONCOMPOSTED SLUDGE	COMPOSTED SLUDGE	TOTAL	FREQUENCY OF TESTING	POLLUTANT TESTING COST/YR[b]	PATHOGEN TESTING COST/YR	COST OF CONTRACT	COST OF OTHER RECORDKEEPING	COST OF REPORTING	TOTAL COST
0.1 MGD	1,066	0	1,066	1/yr	$ 903,968	$ 106,600	$ 45,036[a]	$ 559,650	$159,900	$1,775,154
0.5 MGD	868	1	869	1/yr	737,067	86,900	36,612[b]	456,225	130,350	1,447,154
2 MGD	566	25	591	4/yr	2,020,172	236,400	24,948	310,275	354,600	2,946,395
14 MGD	62	3	65	1/mo	667,020	78,000	2,592	34,125	117,000	898,737
128 MGD	7	0	7	1/mo	71,232	8,400	3,675	3,675	12,600	96,231
Total	2,569	29	2,598[c]		$4,399,459	$516,300	$109,512	$1,363,950	$774,450	$7,163,671

[a] Does not include one POTW generating 98th percentile sludge that is estimated to shift to codisposal.

[b] Does not include three POTWs generating 98th percentile sludge that are estimated to shift to codisposal.

[c] 25 POTWs will shift to codisposal and thus will not incur testing costs. Five 0.1-MGD POTWs and twenty 0.5-MGD POTWs will shift to codisposal.

Source: ERG estimates.

TABLE 4-56

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWS PRACTICING LAND APPLICATION UNDER OPTION 3 ($1987)

SIZE	MONITORING, RECORDKEEPING, AND REPORTING COSTS	AGRICULTURAL LAND APPLICATION SHIFTING COSTS		NON-AGRICULTURAL SHIFTING COSTS[a]	TOTAL
		90TH PERCENTILE SLUDGES	98TH PERCENTILE SLUDGES		
0.1 MGD	$1,775,154	$26,158	$8,976	$7,480	$1,817,768
0.5 MGD	1,447,154	122,655	197,136	157,842	1,924,787
2 MGD	2,946,395	1,432,455	3,001,525	870,420	8,250,795
14 MGD	898,737	548,416	1,626,552	0	3,073,705
128 MGD	96,231	0	0	0	96,231
TOTAL	$7,163,671	$2,129,684	$4,834,189	$1,035,742	$15,163,286

[a] Nonagricultural end uses include dedicated disposal, reclamation, and "other."

Source: ERG estimates.

disposal. In this way, POTWs practicing distribution and marketing were distinguished from land appliers.

4.3.4.1 Overview of the Proposed Regulation

The regulation defines maximum pollutant concentrations in the distributed/marketed product depending on application rate. At higher application rates, the concentrations of pollutants in the sludge must be significantly lower than those specified for lower application rates.

Sludge must be monitored at the same frequency as that for land application: once per year at POTWs processing less than 1 MGD; once per quarter at POTWs processing between 1 and 10 MGD; and once per month at POTWs processing more than 10 MGD. Reporting and recordkeeping requirements, such as the maintenance of contracts where possible with sludge end users, sludge testing results, a copy of handouts or labels, and appropriate whole sludge application rates, are also defined.

Distribution and marketing management practices are also specified in the regulation. Bagged sludge must be labeled and bulk sludge must be accompanied with a handout. Both labels and handouts must include the name and address of distributor; a statement that the product contains sewage sludge; a prohibition against using the product on frozen, flooded, or snow-covered land; instructions on the use of the product, including the annual product application rate; and a warning to keep the product out of reach of children until incorporated into the soil.

The regulation also requires that the sludge meet Class A pathogen/vector attraction reduction requirements. Class A pathogen reduction is the highest (i.e., most stringent) level of control specified for sludge, as discussed in Section 4.3.3.

4.3.4.2 Methodology

For purposes of this analysis, composted sludge is used as a proxy for distributed and marketed sludge. Thus, POTWs known to compost sewage sludge and the quantities of sludge known to be composted were used to approximate the number of POTWs and volumes of sludge involved in distribution and marketing.

Since composted sludge is mixed with bulking agents such as woodchips before being distributed, a dilution factor was incorporated before the pollutant concentrations were compared to the numerical criteria. The dilution factor derivation was presented in Section 4.2.2. To determine maximum rates of application, these final concentrations were then compared to the limiting factors. At each rate of application, a different pollutant concentration must be met. The regulation requires that the POTW identify the concentration of each regulated pollutant in its sludge; then, on the chart provided in the regulation, the operator must circle the lowest concentration that is equal to or higher than the actual concentration of that pollutant in the sludge. When all pollutant concentrations have been circled, the circled pollutant concentration farthest to the left on the chart specifies the column to be used to define the appropriate application rate. At the bottom of this column is a number that specifies the highest rate at which the sludge should be applied. Since the sludge has been diluted during the composting process, it is the concentrations of pollutants in the composted sludge that are used to define the appropriate application rate.

4.3.4.3 Results

The results of the application rate analyses are presented in Tables 4-57 through 4-59. According to this analysis, typical sludges can be applied at 10 DMT per hectare, 90th percentile sludges at 3 DMT per hectare, and 98th percentile sludges at 1 DMT per hectare.

TABLE 4-57

DISTRIBUTION AND MARKETING POLLUTANT LIMITS FOR TYPICAL SLUDGES

POLLUTANT	MAXIMUM SEWAGE SLUDGE CONCENTRATION (MILLIGRAMS PER KILOGRAM - DRY WEIGHT BASIS)											
Aldrin/dieldrin	16	5.5	3.3	1.6	1.1	0.82	0.66	0.55	0.47	0.41	0.36	0.33
Arsenic	700	230	140	70	47	35	28	23	20	18	16	14
Benzo(a)pyrene	80	26	15	8	5.1	3.8	3.1	2.6	2.2	1.9	1.7	1.5
Cadmium	800	280	170	80	56	42	34	28	24	21	19	17
Chlordane	22,500	7,500	4,500	2,200	1,500	1,100	900	750	640	560	500	450
Chromium	10,000	3,300	2,000	1,000	666.7	500	400	333.3	285.7	250	220	200
Copper	2,300	770	460	230	150	110	92	77	66	57	51	46
DDT/DDE/DDD (total)	46	15	9.2	4.6	3.1	2.3	1.8	1.5	1.3	1.2	1	0.92
Heptachlor	79	26	16	7.9	5.3	3.9	3.2	2.6	2.3	2	1.8	1.6
Hexachlorobenzene	27	9	5.3	2.7	1.8	1.3	1.1	0.9	0.8	0.67	0.59	0.53
Hexachloro-butadiene	41,000	14,000	8,200	4,100	2,700	2,100	1,600	1,400	1,200	1,000	910	820
Lead	4,000	1,300	800	400	300	190	150	130	110	100	90	80
Lindane	293,500	97,800	58,700	29,350	19,570	14,680	11,740	9,780	8,390	7,340	6,500	5,870
Mercury	780	260	160	78	52	39	31	26	22	19	17	16
Nickel	3,900	1,300	780	390	260	200	160	130	110	98	87	78
Polychlorinated biphenyls	49	49	49	46	31	23	18	15	13	11	10	9
Selenium	8,106	2,702.1	1,600	810	540	410	320	270	230	200	180	160
Toxaphene	117	39	23	12	7.8	5.8	4.7	3.9	3.3	2.9	2.6	2.3
Zinc	8,600	2,900	1,700	860	570	430	340	290	250	220	190	170
	1	3	5	10	15	20	25	30	35	40	45	50

ANNUAL WHOLE SLUDGE APPLICATION RATE
(METRIC TONS PER HECTARE)

Source: ERG estimates; Part 503 proposed Sewage Sludge Technical Regulation.

TABLE 4-58

DISTRIBUTION AND MARKETING POLLUTANT LIMITS FOR 90TH PERCENTILE SLUDGES

POLLUTANT	MAXIMUM SEWAGE SLUDGE CONCENTRATION (MILLIGRAMS PER KILOGRAM - DRY WEIGHT BASIS)											
Aldrin/dieldrin	16	5.5	3.3	1.6	1.1	0.82	0.66	0.55	0.47	0.41	0.36	0.33
Arsenic	700	230	140	70	47	35	28	23	20	18	16	14
Benzo(a)pyrene	80	26	15	8	5.1	3.8	3.1	2.6	2.2	1.9	1.7	1.5
Cadmium	800	280	170	80	56	42	34	28	24	21	19	17
Chlordane	22,500	7,500	4,500	2,200	1,500	1,100	900	750	640	560	500	450
Chromium	10,000	3,300	2,000	1,000	666.7	500	400	333.3	285.7	250	220	200
Copper	2,300	770	460	230	150	110	92	77	66	57	51	46
DDT/DDE/DDD (total)	46	15	9.2	4.6	3.1	2.3	1.8	1.5	1.3	1.2	1	0.92
Heptachlor	79	26	16	7.9	5.3	3.9	3.2	2.6	2.3	2	1.8	1.6
Hexachlorobenzene	27	9	5.3	2.7	1.8	1.3	1.1	0.9	0.8	0.67	0.59	0.53
Hexachloro-butadiene	41,000	14,000	8,200	4,100	2,700	2,100	1,600	1,400	1,200	1,000	910	820
Lead	4,000	1,300	800	400	300	190	150	130	110	100	90	80
Lindane	293,500	97,800	58,700	29,350	19,570	14,680	11,740	9,780	8,390	7,340	6,500	5,870
Mercury	780	260	160	78	52	39	31	26	22	19	17	15
Nickel	3,900	1,300	780	390	260	200	160	130	110	98	87	78
Polychlorinated biphenyls	49	49	49	46	31	23	18	15	13	11	10	9
Selenium	8,106	2,702.1	1,600	810	540	410	320	270	230	200	180	160
Toxaphene	117	39	23	12	7.8	5.8	4.7	3.9	3.3	2.9	2.6	2.3
Zinc	8,600	2,900	1,700	860	570	430	340	290	250	220	190	170
	1	3	5	10	15	20	25	30	35	40	45	50
	ANNUAL WHOLE SLUDGE APPLICATION RATE (METRIC TONS PER HECTARE)											

Source: ERG estimates; Part 503 proposed Sewage Sludge Technical Regulation.

2065S/2

TABLE 4-59

DISTRIBUTION AND MARKETING POLLUTANT LIMITS FOR 98TH PERCENTILE SLUDGES

POLLUTANT	MAXIMUM SEWAGE SLUDGE CONCENTRATION (MILLIGRAMS PER KILOGRAM - DRY WEIGHT BASIS)											
Aldrin/dieldrin	16	5.5	3.3	1.6	1.1	0.82	0.66	0.55	0.47	0.41	0.36	0.33
Arsenic	700	230	140	70	47	35	28	23	20	18	16	14
Benzo(a)pyrene	80	26	15	8	5.1	3.8	3.1	2.6	2.2	1.9	1.7	1.5
Cadmium	800	260	170	80	56	42	34	28	24	21	19	17
Chlordane	22,500	7,500	4,500	2,200	1,500	1,100	900	750	640	560	500	450
Chromium	10,000	3,300	2,000	1,000	666.7	500	400	333.3	285.7	250	220	200
Copper	2,300	770	460	230	150	110	92	77	66	57	51	46
DDT/DDE/DDD (total)	46	15	9.2	4.6	3.1	2.3	1.8	1.5	1.3	1.2	1	0.92
Heptachlor	79	26	16	7.9	5.3	3.9	3.2	2.6	2.3	2	1.8	1.6
Hexachlorobenzene	27	9	5.3	2.7	1.8	1.7	1.1	0.9	0.8	0.67	0.59	0.53
Hexachloro-butadiene	41,000	14,000	8,200	4,100	2,700	2,100	1,600	1,400	1,200	1,000	910	820
Lead	4,000	1,300	800	400	300	190	150	130	110	100	90	80
Lindane	293,500	97,800	58,700	29,350	19,570	14,680	11,740	9,780	8,390	7,340	6,500	5,870
Mercury	780	260	160	78	52	39	31	26	22	19	17	16
Nickel	3,900	1,300	780	390	260	200	160	130	110	98	87	78
Polychlorinated biphenyls	49	49	49	46	31	23	18	15	13	11	10	9
Selenium	8,106	2,702.1	1,600	810	540	410	320	270	230	200	180	160
Toxaphene	117	39	23	12	7.8	5.8	4.7	3.9	3.3	2.9	2.6	2.3
Zinc	8,600	2,900	1,700	860	570	430	340	290	250	220	190	170
ANNUAL WHOLE SLUDGE APPLICATION RATE (METRIC TONS PER HECTARE)	1	3	5	10	15	20	25	30	35	40	45	50

Source: ERG estimates; Part 503 proposed Sewage Sludge Technical Regulation.

4.3.4.4 Compliance Costs

Compliance costs for POTWs that practice distribution and marketing of sewage sludge include management practice costs and costs of shifting to alternative disposal methods. Each of these cost categories is discussed below.

Shifts in Disposal Practice

According to the current analysis, POTWs generating 90th and 98th percentile sludges will have to shift to alternative disposal methods. Of those POTWs with 90th percentile sludges, approximately 70 percent (21 POTWs) dispose of their sludge using nonagricultural end uses (see Section Three for the breakdown of end uses for composted sludges). Since POTWs were classified as practicing distribution and marketing if they composted their sludge, these POTWs may be more appropriately considered to practice land application. Thus, these POTWs are assumed to shift to nonagricultural land application. The remainder of these POTWs (30 percent or 9 POTWs) either use their sludge for agricultural end uses or provide sludge to brokers or directly to consumers. (The 90th percentile sludge fails agricultural limits even after composting.) These POTWs are assumed to shift to incineration. Codisposal is not considered to be available to POTWs practicing composting. It is assumed that these POTWS would have already chosen codisposal over the more expensive composting alternative, if they could.

Among the POTWs with 98th percentile sludges, 70 percent (4 POTWs) are assumed to be able to shift to land application. These sludges will pass the maximum pollutant concentrations for nonagricultural land application due to the dilution associated with the composting process. Only the 30 percent of POTWs assumed to generate 98th percentile sludges that are used for agricultural application or go to brokers or consumers will have to shift to alternative disposal methods. Only one POTW (in the 2-MGD size class) meets this definition and would need to shift to incineration.

The costs of shifting to incineration are presented in Table 4-60. As the table shows, the annual compliance costs associated with shifts in disposal practices are $6.8 million.

Management Practice Costs

Management practice costs include the costs of preparing labels and handouts for distributed sludge; monitoring sewage sludge quality, including pollutant levels, pathogens, and vector attraction parameters; recordkeeping, including the maintenance of contracts; reporting; reducing application rates; and meeting pathogen reduction requirements. These costs are discussed below.

Labeling and Handout Development. The POTW must develop and distribute a handout to users of the composted or heat treated sludge. Bagged sludge products must have labels with the same printed information. The name and address of the producer, a description of the product, recommended soil pH, instructions for proper use of the product, plant nutrient values, and several prohibitions must be included in the handout or on the label.

As discussed in Section 4.2.3, a few states already require labeling, but all the required information may not be included on the existing handouts or labels. Additions may have to be made to comply with the proposed regulations in these circumstances. The majority of POTWs using distribution and marketing will have to develop this material. It was assumed that 16 hours of the assistant superintendent's and 4 hours of a clerical staff person's time would be needed to fulfill labeling requirements each year. Hourly labor rates are $14.42 and $10.49 respectively. In addition, copy charges for 500 one-page printed handouts at $0.10 per page were allotted. The total annual cost per POTW is $324. If states already require labeling, only a portion of these costs will be relevant. Total annual labeling costs for the 71 POTWs that are estimated to continue using distribution and marketing for disposal of sludge are $23,004.

TABLE 4-60

ANNUAL INCREMENTAL COSTS OF SHIFTING FROM DISTRIBUTION AND MARKETING TO INCINERATION UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS	INCREMENTAL COST/DMT[a]	TOTAL COST OF SHIFTING
0.1 MGD	0	$ NE	$ 0
0.5 MGD	2	2,766	614,052
2 MGD	4	850	1,513,000
14 MGD	2	322	2,006,704
128 MGD	2	46	2,619,976
Total	10		$6,753,732

[a] Includes costs of meeting pollution control requirements.

NE = Not estimated.

Source: ERG estimates.

Note: DMT = Dry metric ton.

Pathogen and Vector Attraction Reduction. Sludges that are distributed and marketed must meet Class A pathogen and vector attraction reduction requirements. This level of reduction should be achieved when sewage sludge is properly composted. No incremental costs associated with meeting Class A Pathogen and Vector Attraction Reduction requirements are incurred.

Reduction of Application Rates. As the results of the pass/fail analysis show, all sludge types can potentially pass the criteria, as long as application rates are at 10 DMT/ha for typical sludges, 3 DMT/ha for 90th percentile sludges, and 1 DMT/ha for 98th percentile sludges. Typical application rates for distributed and marketed sludges are likely to be similar to those for agricultural land application since composted sludge goes to some of the same or similar end uses. The required application rate of 10 DMT/ha is close to a typical rate for agricultural land application (11 DMT/ha was used in the analysis in Section 4.3.3). The application of typical sludges at this rate is estimated to be associated with negligible incremental costs.

The reduction of application rates to 3 or 1 DMT/ha is considered unlikely. The current supply of composted sludge meets the current demand for sludge products in any area in which composted sludge is readily available. Lowering the prescribed application rates by these amounts effectively lowers the demand for sludge. The market for 90th percentile sludge would have to triple and the market for 98th percentile sludges would have to increase 10 times for the same quantity of these sludges to be disposed of in this manner. It seems unlikely that market expansion of this magnitude could occur. Thus, it is assumed that the 35 POTWs estimated to generate 90th and 98th percentile sludges would shift to alternative disposal methods.

Sludge Monitoring, Recordkeeping and Reporting. Yearly sludge testing for small POTWs, quarterly testing for mid-size POTWs, and monthly testing for large POTWs must be performed for pollutants, pathogens and vector attraction parameters. Existing state regulations require some testing for pollutants, but not at the same frequency or for all the pollutants covered by the regulations. It is thus assumed that all testing costs are incremental.

Using this assumption overstates the incremental costs of testing, but this overestimation is believed to be minor, since most states require testing only for a few metals at fairly infrequent intervals. When queried, testing laboratories indicated that pollutant testing costs for metals in composted sludges are $18 per metal; pollutant testing costs for all organics are $823. Testing for pathogens is estimated at $100 per test, and costs for testing for vector attraction parameters are estimated to be negligible.

The POTWs shifting to incineration will also need to test for seven metals at the same frequency at a cost of $15 per metal and will also have to meet the recordkeeping and reporting requirements for incinerators. As for other disposal methods, recordkeeping tasks for distribution and marketing are estimated to cost about $525 per POTW; additionally, most of the 96 POTWs that do not shift to incineration will be required to write contracts. About 13 percent of all distributed and marketed sludge goes to the general population. It is assumed, therefore, that 13 percent of the POTWs generating typical sludges will not be able to write contracts (9 POTWs). Of the remaining 25 POTWs, all are assumed capable of writing contracts (all POTWs estimated to provide 90th or 98th percentile sludge to the general population are estimated to shift to incineration). Therefore, 87 POTWs are expected to write contracts at a cost of $324/year, or a total of $28,188. Table 4-61 presents the monitoring, recordkeeping and reporting costs for POTWs practicing distribution and marketing and for POTWs shifting to incineration. As the table shows, total first-year incremental monitoring, recordkeeping, and reporting costs are $1.0 million. Costs in subsequent years are $914,462.

Summary of Compliance Costs

Table 4-62 summarizes the estimated annual compliance costs associated with sludge testing and shifts in disposal practices. The total first-year incremental costs for POTWs using distribution and marketing are $7.8 million. In subsequent years, these costs total $7.7 million.

TABLE 4-61

ANNUAL SLUDGE TESTING COSTS FOR POTWS PRACTICING DISTRIBUTION AND MARKETING OR SHIFTING TO INCINERATION UNDER OPTION 3
($1987)

SIZE	NO. OF POTWS TESTING COMPOSTED SLUDGE	NO. OF POTWS SHIFTING TO INCINERATION	MONITORING AND REPORTING REQUIREMENT	MONITORING COST PER YEAR FOR POTWS WITH COMPOSTED SLUDGE	MONITORING COST PER YEAR FOR POTWS SHIFTING TO INCINERATION	TOTAL ANNUAL TESTING COSTS	CONTINUOUS MONITORING AND RECORDING (INCINERATORS)	PERFORMANCE TESTING AND DISPERSION MODELLING (INCINERATORS)	CONTRACT COSTS (O&M)	OTHER RECORD-KEEPING COSTS	REPORTING COSTS	LABELING COSTS	TOTAL COSTS*
0.1 MGD	5	0	1 yr.	$ 1,085	$ 105	$ 5,425	$ 0	$ 0	$1,620	$2,625	$ 750	$ 1,296	$ 11,716
0.5 MGD	25	2	1 yr.	1,085	105	27,335	36,140	25,662	7,128	14,175	4,050	6,804	121,294
2 MGD	41	4	4 yr.	4,340	420	179,620	72,280	51,324	11,988	23,625	27,000	9,720	375,557
14 MGD	14	2	1 mo.	13,020	1,260	184,800	36,140	25,662	4,212	8,400	28,800	2,916	290,930
138 MGD	11	2	1 mo.	13,020	1,260	145,740	36,140	25,662	3,240	6,825	23,400	23,004	243,275
Total	96	10				$542,920	$180,700	$128,310	$28,188	$55,650	$84,000	$23,004	$1,042,772

*These are first year costs. Costs in subsequent years are $914,462.

Source: ERG estimates.

2066B

TABLE 4-62

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWS USING DISTRIBUTION AND MARKETING UNDER OPTION 3

($1987)

SIZE	MONITORING, RECORDKEEPING, & REPORTING COSTS	SHIPPING COSTS	TOTAL COSTS[a]
0.1 MGD	$11,716	$0	$11,716
0.5 MGD	121,294	614,052	735,346
2 MGD	375,557	1,513,000	1,888,557
14 MGD	290,930	2,006,704	2,297,634
128 MGD	243,275	2,619,976	2,863,251
Total	$1,042,772	$6,753,732	$7,796,504

[a] These are first year costs. In subsequent years, total costs will be $7,668,194.

Source: ERG estimates.

2061S

Total residents served using distribution and marketing end uses number 16.3 million. Assuming three persons per household, total first-year incremental costs can be expressed as $1.44 per household per year for POTWs using distribution and marketing. In subsequent years, this cost is $1.41. In addition to the residential population, commercial and industrial customers are also a part of the total population served. The incremental costs, therefore, would be spread over all customers and the actual per-household increment would be reduced.

4.3.5 Costs and Impacts of Regulatory Option 3 Governing Disposal of Sewage Sludge in Surface Impoundments

This section summarizes the costs and impacts of regulatory Option 3 on the disposal of sewage sludge in surface impoundments. Surface impoundments are not covered as a part of regulations in Proposed 40 CFR Part 258, which governs Subtitle D disposal. The section of the proposed sewage sludge regulations regarding sludge surface impoundments incorporates sections of the proposed Part 258 RCRA amendments, and also contains mandates unique to this rulemaking.

4.3.5.1 Overview of the Proposed Regulations

The proposed Option 3 regulations governing surface impoundments include numerical criteria, siting requirements, and acceptable management practices designed to minimize adverse effects to human health and the environment. The proposed regulation affects owners and operators of sewage sludge surface impoundments that are on or separate from the POTW site. Data on surface impoundments are scanty, so many assumptions have been made regarding the number of POTWs that use surface impoundments for disposal. In the 1986 Needs Survey, a total of 5,669 POTWs have been identified as practicing "other" disposal methods. Since these "other" methods are not defined, EPA used certain information on sludge handling processes to determine which POTWs might be using impoundments as disposal methods. Within the "other" disposal category, POTWs noted that they used a variety of lagoon or pond types, including stabilization lagoons, drying lagoons, air drying beds, aeration lagoons, stabilization ponds, containment ponds, and others.

The regulation is intended to cover only impoundments (or waste piles) that are used for long-term storage (over one year) or disposal. Treatment lagoons are specifically excluded. Some of the lagoons noted by POTWs are almost certainly used for treatment. Aeration lagoons and air drying typically involve the installation of capital equipment, such as aeration pumps or drainage systems. Thus these types of sludge handling processes have been assumed to be treatment processes only. Stabilization ponds, containment ponds, drying lagoons and other sludge disposal (which may include waste piles) are believed more likely to be long-term storage or disposal processes, although some are very likely to be used for treatment. The percentage of POTWs using these processes for long-term storage or disposal is not known. It has thus been assumed for this analysis that 50 percent of the stabilization ponds, containment ponds, drying lagoons, and other are surface impoundments used for long-term storage or disposal, or 42 percent of the total 5,669 POTWs practicing "other" disposal methods (2,395 POTWs).

The numerical criteria for surface impoundments have been based on the 98th percentile sludge concentrations, as were those for nonagricultural land application. These criteria specify maximum sewage sludge concentrations of priority toxic pollutants for 5 metals and 10 organics. Sludge monitoring for pollutants, pathogens, and vector attraction parameters is required at varying frequencies based on POTW size. POTWs processing less than 1 MGD must test annually; those processing 1 to 10 MGD must test quarterly; and those processing more than 10 MGD must test monthly. Reports must be written on the same schedule and recordkeeping requirements, such as sludge testing results, certifications, and volumes of runoff treated and discharged, are specified as well.

The siting requirements restrict the operation of surface impoundments in floodplains, wetlands, seismic zones, fault zones, unstable areas, and areas located near airports.

The proposed regulation specifies management practices that define minimum acceptable operating procedures for surface impoundments. The following items are addressed: methane limits, access, runon/runoff control systems, and recordkeeping and reporting.

4.3.5.2 Methodology

The analysis of compliance costs proceeded in two stages. First, an evaluation of the numerical criteria was performed to determine how many POTWs would meet these limits. Second, the costs of complying with the criteria and the management practices were compiled for all POTWs passing the criteria.

The criteria were analyzed using the three sludge concentration profiles established in Section Three of this report to represent POTWs with typical sludges, 90th percentile sludges, and 98th percentile sludges. The POTWs believed to use sludge surface impoundments were assigned to these three groups based on the percent industrial contribution to each plant. (See discussion in Section Three for details of the assignment procedure.) A pass/fail analysis was performed by comparing the three sludge profiles to the maximum allowable pollutant concentrations for sludges disposed of in surface impoundments.

Baseline practices were compared to the proposed requirements to determine incremental cost items associated with the management practices in the proposed regulations. The baseline was established as current state and federal regulations.

4.3.5.3 Results

Pass/Fail Analysis

Table 4-63 shows the pass/fail results of comparing the three sludge profiles representing typical sludges, 90th percentile sludges, and 98th

TABLE 4-63. PASS/FAIL ANALYSIS FOR SURFACE IMPOUNDMENTS UNDER OPTION 3

	CONCENTRATIONS IN SLUDGE PROFILES (MG/KG)			MAXIMUM SLUDGE CONC.	PASS/FAIL		
POLLUTANT	TYPICAL	90th PERC.	98th PERC.	(MG/KG)	TYPICAL	90th PERC.	98th PERC.
ARSENIC	4.359	16.39	36.4	36	PASS	PASS	FAIL
CADMIUM	11.189	101.72	384.6	385	PASS	PASS	PASS
LEAD	265.741	821.87	1622.8	1622	PASS	PASS	FAIL
MERCURY	1.735	7.21	17	17	PASS	PASS	PASS
BENZENE	0.336487	3.6598	15.42	15	PASS	PASS	FAIL
BAPYRENE	0.001	0.234	6.911	99	PASS	PASS	PASS
BEHP	104.796	367.158	781.527	782	PASS	PASS	PASS
DDT/DDE/DDD	0.006713	0.0331443	0.0872404	0.95	PASS	PASS	PASS
DMN	0.281	0.78	1.445	1.4	PASS	PASS	FAIL
LINDANE	0.004865	0.0294687	0.0872404	2.3	PASS	PASS	PASS
PCB	0.004865	0.0294687	0.0872404	49	PASS	PASS	PASS
TOXAPHENE	0.004865	0.0294687	0.0872404	0.5	PASS	PASS	PASS
TCE	0.529272	20.1945	181.22	181	PASS	PASS	FAIL
NICKEL	70.114	365.39	988	988	PASS	PASS	PASS
COPPER	411	1507.94	3300.3	3300	PASS	PASS	FAIL
CHLORDANE	0.004865	0.0294687	0.0872404	180	PASS	PASS	PASS

Source: ERG estimates.

percentile sludges to the maximum allowable sludge concentrations listed in the proposed regulation. Of the POTWs that are believed to use surface impoundments, 2,289 are in the typical sludge category, 81 in the 90th percentile category, and 25 in the 98th percentile category. If the model sludge concentration for a particular pollutant exceeds its maximum allowable concentration, a "fail" is registered in the table for that pollutant. All pollutants must pass for the sludge to satisfy the requirements of the regulation. According to the analysis in Table 4-63, all but the POTWs generating 98th percentile sludges would pass all the pollutant limits.

4.3.5.4 Compliance Costs

Those facilities that pass the numerical criteria will be subject to the siting and management practice requirements in the proposed regulation. The management practice requirements that are incremental to baseline requirements are the siting criteria and minimum operating procedures, including sludge monitoring, recordkeeping and reporting requirements. The costs of these requirements as well as the costs of shifting to alternative disposal methods are discussed below.

Shifts in Disposal Practice

All POTWs generating 98th percentile sludges now using surface impoundments as a disposal option (estimated at 25 facilities) are assumed to shift to an alternative disposal method because they are projected to fail the criteria. As discussed in Section 4.2.2, alternative disposal methods are limited. The smallest facilities (those represented by the 0.1-MGD and 0.5-MGD model facilities) are assumed to be able to shift to municipal landfills for disposal. Shifting to disposal at a municipal landfill is a realistic alternative for facilities in these small size categories. The larger facilities, however, with their potential for significant impact on municipal landfill capacity problems, are assumed to shift either to incineration or to composting with subsequent dedicated land application, depending on the cost-effectiveness of the option for each size model facility. As for nonagricultural land application, POTWs can meet the 98th percentile sludge criteria when the sludge is composted, due to dilution. The only facility size expected to use incineration is the 128-MGD facility. Costs for incinerating sludge under Option 3 requirements for this size facility were developed in previous sections. No POTWs in this size class are expected to fail the criteria, however.

The baseline costs for codisposal were developed in Section Three, Table 3-31, and range from $290 to $340/DMT for codisposal for the 20 failing facilities in the 0.5-MGD and 0.1-MGD size classes, respectively.

Costs for impoundments have been assumed similar to the costs of agricultural land application, since impoundments are not as labor-intensive as either monofills, reclamation, or dedicated disposal. Actual costs for impoundments will be modeled at a later date.

Incremental costs per dry metric ton for the disposal alternatives under Option 3 thus range from $102 to $326/DMT (see Table 4-64). The incremental costs of shifting disposal practice are also shown in Table 4-64. Total annual incremental costs of shifting disposal practices are $1.3 million.

Monitoring, Recordkeeping and Reporting

All POTWs that are currently using surface impoundments are expected to shift to codisposal or to composting and dedicated land application as a result of Option 3 requirements. Those POTWs shifting to codisposal will not be required to monitor their sludge quality, but those shifting to composting and dedicated land application will be required to test for the 10 metals and the organics that are covered by the nonagricultural land application criteria, as well as for pathogens and vector attraction parameters. All POTWs passing the criteria will also have to test for these items, although they will only have to test for five metals. The frequency of sludge testing varies by POTW size, with POTWs generating less than 1 MGD wastewater required to test annually, those generating 1 to 10 MGD required to test quarterly and those generating more than 10 MGD required to test monthly.

TABLE 4-64

ANNUAL INCREMENTAL COST OF SHIFTING FROM SURFACE IMPOUNDMENTS TO ALTERNATIVE DISPOSAL METHODS UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS	ALTERNATIVE DISPOSAL METHOD	INCREMENTAL COST PER DMT	TOTAL COST PER FACILITY
0.1 MGD	10	Codisposal	$102	$22,440
0.5 MGD	10	Codisposal	111	123,210
2 MGD	4	Composting and dedicated land application	355	631,900
14 MGD	1	Composting and dedicated land application	174	542,184
128 MGD	0	Incineration	46	0
Total	25			$1,319,734

Source: ERG estimates.

Note: DMT = Dry metric ton.

A total of 2,375 POTWs (20 POTWs are estimated to shift to codisposal) will have to test for pathogens at $100 per test and for vector reduction parameters (assumed to have a negligible cost). They will also have to perform recordkeeping and reporting tasks, which are estimated to cost $525 per facility and $150 per facility per reporting period, respectively. These costs were derived in Section 4.3.1.

Incremental costs for monitoring, recordkeeping and reporting, shown in Table 4-65, total $4.0 million.

Other Management Practice Requirements

Methane monitoring, runon/runoff controls and siting requirements are also specified in the regulation. These potentially incremental requirements have not been costed at this time.

Total Compliance Costs

Total first-year costs associated with the Option 3 requirements for surface impoundments, including shifting disposal methods, sludge monitoring, recordkeeping and reporting are $5.5 million (see Table 4-66). In subsequent years, these costs are $5.4 million.

Approximately 6.1 million residents are estimated to be served by POTWs using sludge impoundments. Assuming three residents per household, total first-year incremental costs associated with the proposed monofill regulations are $2.70 per household. In subsequent years, this cost is $2.67. Actual costs per household would be somewhat lower than this because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

TABLE 4-65

ANNUAL SEWAGE SLUDGE MONITORING, RECORDING, AND RECORDKEEPING COSTS FOR POTWS SHIFTING FROM SURFACE IMPOUNDMENTS TO COMPOSTING AND LAND APPLICATION UNDER OPTION 3

($1987)

SIZE	NO. OF POTWS PASSING CRITERIA (NON-COMPOSTED SLUDGE)	NO. OF POTWS SHIFT-ING TO COMPOSTING AND LAND APPLICATION	FREQUENCY OF MONITORING AND REPORTING	SLUDGE TESTING COSTS/ YEAR (NONCOM-(POSTED SLUDGE)[a]	SLUDGE TESTING COSTS/ YEAR (COMPOSTED SLUDGE)[a]	RECORD-KEEPING COSTS	REPORTING COSTS	TOTAL ANNUAL INCREMENTAL COST OF MONITORING, RECORD-KEEPING AND REPORTING
0.1 MGD	1,958	10[b]	1/yr	1,709,334	0	1,027,950	293,700	3,030,984
0.5 MGD	348	10[b]	1/yr	303,804	0	182,700	52,200	538,704
2 MGD	55	4	4/yr	192,060	17,648	30,975	35,400	276,083
14 MGD	8	1	1/mo	83,808	13,236	4,725	16,200	117,969
128 MGD	1	0	1/mo	10,476	0	525	1,800	12,801
Total	2,370	25		2,299,482	30,884	1,246,875	399,300	3,976,541

[a] Includes costs of pathogen testing and pollutant testing.

[b] These POTWs are extimated to shift to codisposal.

Source: ERG estimates.

TABLE 4-66

TOTAL ANNUAL INCREMENTAL COSTS OF COMPLIANCE FOR POTWS USING SURFACE IMPOUNDMENTS UNDER OPTION 3

($1987)

SIZE	MONITORING, RECORDKEEPING, AND RECORDING COSTS	SHIFTING COSTS	TOTAL COSTS
0.1 MGD	$3,030,984	22,440	3,053,424
0.5 MGD	538,704	123,210	661,914
2 MGD	276,083	631,900	907,983
14 MGD	117,969	542,184	660,153
128 MGD	12,801	0	12,801
Total	3,976,541	1,319,734	5,296,275

Source: ERG estimates.

4.3.6 Summary of Compliance Costs for All Disposal Methods Under Regulatory Option Three

Table 4-67 summarizes all compliance costs for all disposal methods under Regulatory Option 3. Total annual costs of compliance under this option are $157.6 million. Incineration comprises the largest portion of compliance costs at $103.8 million. Costs for monofilling are $25.5 million. Land application costs total $15.2 million. Distribution and marketing costs are $7.8 million, and surface impoundment costs are $5.3 million. Note that the $157.6 million figure represents first-year costs, since the costs of incinerator emissions testing and air dispersion modeling are one-time costs. Costs for subsequent years are $155.2 million.

4.4 Costs and Impacts of Regulatory Option Four

Regulatory Option 4 is similar to Option 3 in that the pollutant limitations were derived from a risk assessment of health effects. Option 4 is more stringent than Option 3 for each disposal method except incineration. Risk levels for carcinogens have been set at 10^{-5} or 10^{-6} (or 1 cancer in a population of 1 million or 100,000, respectively) for all the disposal methods covered. Thus, except for incineration, in which 10^{-5} risk levels were used to define maximum pollutant criteria under both Option 3 and 4, the criteria for each disposal method becomes more stringent under Option 4. In addition, for land application, the risk-based limitations apply to all POTWs under Option 4 instead of only to POTWs employing agricultural end uses. All management practices, such as sludge testing requirements, recordkeeping and reporting, and use and access restrictions, remain the same as those for Option 3 (discussed in Section 4.3). The methodologies used to determine compliance and the costs and impacts associated with meeting the criteria under each disposal method remain basically the same as those for Option 3. Only the number of POTWs affected by the regulatory option may differ.

The sections below discuss the costs and impacts of regulatory Option 4 for five disposal methods. Surface impoundments are not included in the Option 4 analysis. Where no changes in incremental costs are expected between

TABLE 4-67

TOTAL COMPLIANCE COSTS FOR ALL DISPOSAL METHODS UNDER OPTION 3 ($1987)

SIZE	INCINERATION	MONOFILL	LAND APPLICA-CATION	DISTRI-BUTION AND MARKET-ING	TOTAL SURFACE IMPOUNDMENTS	TOTAL COST ALL DISPOSAL METHODS[a,b]
0.1 MGD	$ 0	$ 4,290	$1,817,768	11,716	3,053,424	4,887,198
0.5 MGD	371,757	166,278	1,924,787	735,346	661,914	3,860,082
2 MGD	9,989,728	8,488,079	8,250,795	1,888,557	907,983	29,525,142
14 MGD	23,429,960	12,871,180	3,073,705	2,297,634	660,153	42,332,632
128 MGD	70,013,892	3,964,450	96,231	2,863,251	12,801	76,950,625
Total	$103,805,337	$25,494,277	$15,163,286	$7,796,504	$5,296,275	$157,555,679

[a] Note that depending on choice of pollution control equipment, this total could range from $155 million if all incinerators failing to meet the criteria retrofit fabric filters to $320 million if all incinerators failing to meet the criteria retrofit dry scrubbers plus fabric filters.

[b] The total represents first-year costs since costs of incinerator emissions testing and air dispersion modeling are one-time costs. Costs for recurring years under Option 3 are $155,210,400.

Source: ERG estimates.

Option 3 and Option 4, a brief summary table of Option 3 results is repeated for that disposal method.

4.4.1 Costs and Impacts of Regulatory Option 4 on POTWs Incinerating Sewage Sludge

The criteria that must be met by POTWs incinerating sewage sludge under Option 4 are identical to those under Option 3. Since the criteria are the same, the same 122 POTWs with 219 existing incinerators fail to meet criteria for metals under Option 4 as they did under Option 3 and the same 26 POTWs with 44 existing incinerators fail to meet hydrocarbon emissions limits under Option 4 as they did under Option 3. POTWs that shift from ocean disposal to incineration because of the ban on ocean disposal sludge are assumed, as before, to meet or exceed the requirements of Option 4. The means for complying with the incineration regulations continue to be, for existing incinerators, the addition of pollution control devices (assumed to be wet electrostatic precipitators and afterburners). The same sludge testing requirements apply for Option 4 as for Option 3 and the same number of POTWs are assumed to perform emission testing and air dispersion modeling. Incremental costs, therefore, are the same as those presented for incineration under Option 3. Table 4-68 summarizes these incremental costs for all five POTW size classes. As before, annual incremental costs are $103.8 million. Note that these costs are first-year costs since performance testing and dispersion modeling are one-time costs. In subsequent years, annual costs of compliance are $101.2 million.

The number of residents served by POTWs using existing incinerators is 24.9 million. Assuming three persons per household, the incremental first-year costs in terms of per-household charges are $12.48, based on the incremental costs of compliance for POTWs with existing incinerators provided in the footnote to Table 4-68. In subsequent years, for households served by existing incinerators, the per-household cost is $12.17. The ocean ban POTWs are estimated to incur costs of $281,895 or about $0.09 per household based on a residential population of 9.9 million. Actual costs per household would be somewhat lower since these costs would be apportioned over commercial and industrial customers (in addition to residential customers).

TABLE 4-68

SUMMARY OF COMPLIANCE COSTS FOR INCINERATION OF SEWAGE SLUDGE UNDER OPTION 4

($1987)

SIZE	SLUDGE TESTING RECORDKEEPING AND REPORTING	PERFORMANCE TESTING AND DISPERSION MODELING	MONITORING	POLLUTION CONTROL EQUIPMENT FOR METALS	AFTERBURNERS	TOTAL[a]
0.1 MGD	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
0.5 MGD	3,900	38,493	38,951	39,377	251,036	371,757
2 MGD	114,330	977,501	1,250,420	2,757,039	4,890,438	9,989,728
14 MGD	293,970	1,129,156	1,660,644	10,076,270	10,269,920	23,429,960
128 MGD	118,305	418,789	1,144,870	11,167,617	57,164,311	70,013,892
Total	$530,505	$2,563,939	$4,094,885	$24,040,303	$72,575,706	$103,805,337

[a] This total is for first-year costs. Recurring annual costs will not include the costs of performance testing and dispersion modeling and will total $101,241,398. For POTWs with existing incinerators, total first-year costs are $103,523,442, with recurring costs of $100,959,503.

Source: ERG estimates.

4.4.2 Costs and Impacts of Regulatory Option 4 on POTWs Practicing Monofilling of Sewage Sludge

Under Option 4, the criteria for carcinogens become more stringent than those for Option 3, going from a risk-based level of 10^{-5} to 10^{-6}. As was done in Section 4.3.3, a pass/fail analysis was performed to determine how many POTWs fail these new criteria. As Table 4-69 shows, all POTWs fail the Option 4 monofill criteria. The typical sludge profile fails the criteria for the same pollutants under Option 4 as under Option 3. Since all POTWs also failed the Option 3 criteria, Options 4 and 3 have identical compliance costs. Table 4-70 summarizes the compliance costs developed for Option 3 in the discussion of monofills. The same numbers of POTWs (49 facilities) must shift to alternative disposal methods and, as before, small POTWs (0.1- and 0.5-MGD facilities) are assumed to shift to codisposal. The larger POTWs are assumed to shift to incineration. It is assumed that POTWs cannot use liners and leachate collections systems to meet the criteria for monofills (see discussion in Section 4.3.3.). The POTWs shifting to incineration must test their sludge annually, quarterly, or monthly depending on the volume of wastewater they process and must also perform other monitoring, recordkeeping and reporting tasks. The total first-year incremental costs for POTWs using monofills are $25.5 million based on the methodology discussed in Section 4.3.3. In subsequent years, costs are $25.1 million.

Approximately 1.8 million residents are served by POTWs using sludge monofills. Assuming that POTWs meet the regulatory requirements exclusively by shifting disposal methods and assuming three residents per household, total first-year incremental costs associated with the proposed monofill regulations are $42.86 per household. In subsequent years this cost is $42.21 per household. Actual costs per household would be somewhat lower than this because POTWs have residential, commercial, and industrial customers over which incremental costs would be apportioned.

TABLE 4-69. PASS/FAIL ANALYSIS FOR MONOFILLS UNDER OPTION 4

POLLUTANT	CONCENTRATIONS IN SLUDGE PROFILES (MG/KG)			MAXIMUM SLUDGE CONC. (MG/KG)	PASS/FAIL		
	TYPICAL	90th PERC.	98th PERC.		TYPICAL	90th PERC.	98th PERC.
ARSENIC	4.359	16.39	36.4	24	PASS	PASS	FAIL
CADMIUM	11.189	101.72	384.6	9.44	FAIL	FAIL	FAIL
LEAD	265.741	821.87	1622.8	500	PASS	FAIL	FAIL
MERCURY	1.735	7.21	17	23.6	PASS	PASS	PASS
BENZENE	0.336487	3.6598	15.42	0.85	PASS	FAIL	FAIL
BAPYRENE	0.001	0.234	6.911	25	PASS	PASS	PASS
BEHP	104.796	367.158	781.527	1.39	FAIL	FAIL	FAIL
DDT/DDE/DDD	0.006713	0.0331443	0.0872404	1.72	PASS	PASS	PASS
DMN	0.281	0.78	1.445	0.007	FAIL	FAIL	FAIL
LINDANE	0.004865	0.0294687	0.0872404	49.2	PASS	PASS	PASS
PCB	0.004865	0.0294687	0.0872404	49.9	PASS	PASS	PASS
TOXAPHENE	0.004865	0.0294687	0.0872404	1.11	PASS	PASS	PASS
TCE	0.529272	20.1945	181.22	51.4	PASS	PASS	FAIL

Source: ERG estimates.

TABLE 4-70

TOTAL COST OF COMPLIANCE FOR POTWS USING MONOFILLS UNDER OPTION 4

($1987)

SIZE	NUMBER OF POTWS	TOTAL SHIFTING COST	TOTAL MONITORING RECORDKEEPING AND REPORTING	TOTAL COMPLIANCE COSTS[a]
0.1 MGD	5	$ 4,290	0	$ 4,290
0.5 MGD	14	166,278	0	166,278
2 MGD	19	7,871,605	616,474	8,488,079
14 MGD	10	12,526,320	344,860	12,871,180
128 MGD	1	3,929,964	34,486	3,964,450
TOTAL	49	$24,498,457	$995,820	$25,494,277

[a] These are first-year costs. Costs in subsequent years would be $25,109,347.

Source: ERG estimates.

2165S

4.4.3 Cost and Impacts of Option 4 on POTWs Practicing Land Application of Sewage Sludge

This section describes the regulations regarding the land application of sewage sludge under Option 4 and provides estimates of the associated compliance costs.

4.4.3.1 Overview of Option 4 Regulations

The requirements of the proposed regulations for land application under Option 4 encompass pollutant-specific numeric criteria and management practice requirements. The differences between Option 3 and Option 4 requirements are:

- The numeric criteria, which limit the annual and cumulative pollutant loadings, are more stringent for agricultural land application under Option 4. A risk factor of 10^{-5} rather than 10^{-4} has been used to derive the criteria in Option 4.
- Numeric criteria limiting the annual and cumulative pollutant loadings have been developed for nonagricultural land application under Option 4. The risk factor used to derive criteria for nonagricultural land application under Option 4 is also 10^{-5}. In Option 3, less stringent concentrations, which were not based on a human health risk factor, were used to define criteria for nonagricultural land application. These Option 3 criteria were not expressed as pollutant loadings, but as sludge concentration limits only.

Sludge testing requirements (based on POTW size), recordkeeping and reporting, all pathogen reduction requirements, and access and use restrictions remain the same as those for Option 3 (see discussions of pathogen reduction and access and use restrictions in Section 4.3.4).

4.4.3.2 Methodology

The costs of compliance were developed using a two-stage process. First, a pass/fail analysis was performed. The numeric criteria for both agricultural and nonagricultural land application were compared to the three sludge quality profiles. The results of this pass/fail analysis reflect the number of plants that would be in compliance with the proposed criteria. Additionally, the number of applications of sludge that could be made to each unit of land was determined.

As in Option 3, the pass/fail analysis uses an assumed application rate of 11 dry metric tons per hectare (DMT/ha) to represent typical application rates for agricultural land application. Additionally, application rates for nonagricultural land application were assumed based on rates considered typical for each of the nonagricultural end uses. As discussed in Section 4.3.3, three nonagricultural end uses are common: (1) dedicated disposal, (2) land reclamation and (3) "other," which includes such uses as golf courses, nurseries, and sod farms. A typical application rate for dedicated disposal is 340 DMT/ha; for reclamation, 112 DMT/ha is a typical rate.[15] The application rate for the "other" end use category has been assumed the same as that for agricultural land application - 11 DMT/ha. The loading rate of each contaminant was calculated based on these sludge application rates and the contaminant levels in the sludge. Loading rates were calculated for each of the three sludge quality profiles. The calculated loading rates were compared to the maximum loading rates that correspond to the risk level of 10^{-5}. For the sludge to pass, calculated rates must be lower that maximum allowable rates.

Land appliers that could not meet either annual or cumulative application rate requirements were assumed to shift to the lowest-cost disposal method available. If the sludge could be applied at least once without exceeding the cumulative criteria, the cumulative application rate requirements were assumed to be met.

In the second stage of the analysis, the number of POTWs failing to meet the criteria and the number of POTWs shifting to various alternative disposal practices were estimated; the incremental actions associated with complying with the management practices were established; and associated costs for both management practices and shifts in disposal methods were developed. Current state and federal regulations were the baseline for determining incremental actions. Incremental costs were based on actual costs of material and labor needed to comply with the proposed management practices.

4.4.3.3 Results

Table 4-71 shows that any sludge type (typical, 90th or 98th percentile) applied to agricultural land at a rate of 11 DMT/ha would not pass the Option 4 criteria. The only contaminant causing this failure for typical sludges is trichloroethylene (TCE). If annual pollutant loading criteria had been met, typical sludges could be applied for 10 years; 90th percentile sludges could be applied for 2 years; and 98th percentile sludges would fail the cumulative criteria (since the sludge could not be applied even once in compliance with the criteria).

Tables 4-72, 4-73 and 4-74 show the pass/fail results for nonagricultural land application (dedicated disposal, reclamation, and other, respectively). No specific criteria were developed for the "other" category, so the criteria for silviculture has been assumed to be appropriate for this category. This category was chosen since application rates and end uses in the "other" category are assumed more similar to silviculture than to dedicated disposal or reclamation. As the tables show, no sludge types pass the annual pollutant criteria. As with agricultural land application, the limiting pollutant for typical sludges is TCE, except for dedicated disposal where DMN concentrations are also exceeded. Cumulative application limits for the "other" category are the same as those for agricultural land application. For reclamation and dedicated disposal, 90th and 98th percentile sludge fail to meet cumulative criteria, i.e., sludges cannot be applied even once to land application sites. Typical sludges could be applied once for land reclamation purposes if these sludges had passed the annual application criteria, but typical sludge going to dedicated sites could not be applied once under the cumulative pollutant limits. Thus, for this analysis, the cumulative criteria would be considered to be met only for typical sludges used for land reclamation.

One method of attaining compliance with the criteria would be to reduce the sludge application rate. The sludge application rates assumed in the analysis were chosen to represent typical conditions. In practice, a wide range of application rates are used. The rates required to meet either the agricultural or nonagricultural annual pollutant loading criteria would be impractically low (less than 3 DMT/ha). Thus, reductions in application rates are not considered a realistic means of complying with Option 4 criteria.

TABLE 4-71. PASS/FAIL ANALYSIS FOR LAND APPLICATION - AGRICULTURAL APPLICATION RATE

Pollutant	MAX APPL RATE (KG/HA)	METRIC TONS PER HA 11 TYPICAL (kg/ha)	11 90th PERC. (kg/ha)	11 98 PERC. (kg/ha)	ANNUAL POLLUTANT LOADING PASS FAIL TYPICAL	90th PERC.	98th PERC.	CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATIONS TYPICAL	90th PERC.	98th PERC.
As	14	0.047949	0.18029	0.4006	NA	NA	NA	292.0	77.7	35.0
Cd	16.9	0.123079	1.11892	4.2306	NA	NA	NA	137.3	15.1	4.0
Cr	200	2.729804	13.09704	33.693	NA	NA	NA	73.3	15.3	5.9
Cu	46	4.521	16.58734	36.3033	NA	NA	NA	10.2	2.8	1.3
Pb	77.3	2.923151	9.04057	17.8508	NA	NA	NA	26.4	8.6	4.3
Hg	10.4	0.019085	0.07931	0.187	NA	NA	NA	544.9	131.1	55.6
Mo	1.69	0.145387	0.8624	2.5212	NA	NA	NA	11.6	2.0	0.7
Ni	78	0.771254	4.01929	10.868	NA	NA	NA	101.1	19.4	7.2
Se	25.2	0.015906	0.09966	0.3014	NA	NA	NA	1,584.3	252.9	83.6
Zn	172	10.778174	41.87007	94.8464	NA	NA	NA	16.0	4.1	1.8
A/D	0.00441	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
BAP	0.083	0.000011	0.002574	0.076021	PASS	PASS	PASS			
CLD	0.225	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DDT	0.000547	0.0000738	0.000364587	0.000959644	PASS	PASS	FAIL			
HEPC	0.00729	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
HXBE	0.00435	0.00044	0.006193	0.030283	PASS	FAIL	FAIL			
HXBU	0.0339	0.001232	0.003432	0.006358	PASS	PASS	PASS			
LIN	0.461	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
PCB	0.000564	0.0000535	0.000324155	0.000959644	PASS	PASS	FAIL			
TOX	0.00492	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DMN	0.039	0.003091	0.00858	0.015895	PASS	PASS	PASS			
TCE	0.00127	0.0058219	0.2221395	1.99342	FAIL	FAIL	FAIL			

Source: ERG estimates.

TABLE 4-72. PASS/FAIL ANALYSIS FOR LAND APPLICATION--DEDICATED SITE APPLICATION RATE

		METRIC TONS PER HA			ANNUAL POLLUTANT LOADING			CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATIONS		
		340	340	340	PASS		FAIL			
Pollutant	MAX APPL RATE (KG/HA)	TYPICAL (kg/ha)	90th PERC. (kg/ha)	98 PERC. (kg/ha)	TYPICAL	90th PERC.	98th PERC.	TYPICAL	90th PERC.	98th PERC.
As	23.6	1.48206	5.5726	12.376	NA	NA	NA	15.9	4.2	1.9
Cd	40	3.80426	34.5848	130.764	NA	NA	NA	10.5	1.2	0.3
Cr	15000	84.37576	404.8176	1041.42	NA	NA	NA	177.8	37.1	14.4
Cu	224	139.74	512.6996	1122.102	NA	NA	NA	1.6	0.4	0.2
Pb	77.3	90.35194	279.4358	551.752	NA	NA	NA	0.9	0.3	0.1
Hg	10.4	0.5899	2.4514	5.78	NA	NA	NA	17.6	4.2	1.8
Ni	1080	23.83876	124.2326	335.92	NA	NA	NA	45.3	8.7	3.2
Se	82300	0.49164	3.0804	9.316	NA	NA	NA	167,398.9	26,717.3	8,834.3
Zn	452	333.14356	1294.1658	2931.616	NA	NA	NA	1.4	0.3	0.2
A/D	0.0164	0.0016541	0.010019358	0.029661736	PASS	PASS	FAIL			
BAP	0.134	0.00034	0.07956	2.34974	PASS	PASS	FAIL			
CLD	1.2	0.0016541	0.010019358	0.029661736	PASS	PASS	PASS			
DDT	0.128	0.0022825	0.011269062	0.029661736	PASS	PASS	PASS			
HEPC	0.185	0.0016541	0.010019358	0.029661736	PASS	PASS	PASS			
HXBE	4.13	0.0136	0.19142	0.93602	PASS	PASS	PASS			
HXBU	2420	0.03808	0.10608	0.19652	PASS	PASS	PASS			
LIN	55.5	0.0016541	0.010019358	0.029661736	PASS	PASS	PASS			
PCB	0.201	0.0016541	0.010019358	0.029661736	PASS	PASS	PASS			
TOX	0.0483	0.0016541	0.010019358	0.029661736	PASS	PASS	PASS			
DMN	0.039	0.09554	0.2652	0.4913	FAIL	FAIL	FAIL			
TCE	0.00127	0.1799524	6.86613	61.6148	FAIL	FAIL	FAIL			

Source: ERG estimates.

TABLE 4-73. PASS/FAIL ANALYSIS FOR LAND APPLICATION--RECLAMATION APPLICATION RATE

		METRIC TONS PER HA			ANNUAL POLLUTANT LOADING PASS FAIL			CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATIONS		
Pollutant	MAX APPL RATE (KG/HA)	112 TYPICAL (kg/ha)	112 90th PERC. (kg/ha)	112 98 PERC. (kg/ha)	TYPICAL	90th PERC.	98th PERC.	TYPICAL	90th PERC.	98th PERC.
As	23.6	0.488208	1.83568	4.0768	NA	NA	NA	48.3	12.9	5.8
Cd	40	1.253168	11.39264	43.0752	NA	NA	NA	31.9	3.5	0.9
Cr	200	27.794368	133.35168	343.056	NA	NA	NA	7.2	1.5	0.6
Cu	46	46.032	168.88928	369.6336	NA	NA	NA	1.0	0.3	0.1
Pb	77.3	29.762992	92.04944	181.7536	NA	NA	NA	2.6	0.8	0.4
Hg	10.4	0.19432	0.80752	1.904	NA	NA	NA	53.5	12.9	5.5
Mo	1.69	1.480304	8.7808	25.6704	NA	NA	NA	1.1	0.2	0.1
Ni	78	7.852768	40.92368	110.656	NA	NA	NA	9.9	1.9	0.7
Se	25.2	0.161952	1.01472	3.0688	NA	NA	NA	155.6	24.8	8.2
Zn	172	109.74140	426.31344	965.7088	NA	NA	NA	1.6	0.4	0.2
A/D	0.0164	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
BAP	0.134	0.000112	0.026208	0.774032	PASS	PASS	FAIL			
CLD	0.29	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
DDT	0.0162	0.0007519	0.003712161	0.009770924	PASS	PASS	PASS			
HEPC	0.189	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
HXBE	0.486	0.00448	0.063056	0.308336	PASS	PASS	PASS			
HXBU	304	0.012544	0.034944	0.064736	PASS	PASS	PASS			
LIN	5.4	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
PCB	0.0533	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
TOX	0.0135	0.0005448	0.003300494	0.009770924	PASS	PASS	PASS			
DMN	0.039	0.031472	0.08736	0.16184	PASS	FAIL	FAIL			
TCE	0.00127	0.0592784	2.261784	20.29664	FAIL	FAIL	FAIL			

Source: ERG estimates.

TABLE 4-74. PASS/FAIL ANALYSIS FOR LAND APPLICATION--OTHER APPLICATION RATE

Pollutant	MAX APPL RATE (KG/HA)	METRIC TONS PER HA 11 TYPICAL (kg/ha)	11 90th PERC. (kg/ha)	11 98 PERC. (kg/ha)	ANNUAL POLLUTANT LOADING PASS FAIL TYPICAL	90th PERC.	98th PERC.	CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATIONS TYPICAL	90th PERC.	98th PERC.
As	23.6	0.047949	0.18029	0.4004	NA	NA	NA	492.2	130.9	58.9
Cd	40	0.123079	1.11892	4.2306	NA	NA	NA	325.0	35.7	9.5
Cr	200	2.729804	13.09704	33.693	NA	NA	NA	73.3	15.3	5.9
Cu	46	4.521	16.58734	36.3033	NA	NA	NA	10.2	2.8	1.3
Pb	77.3	2.923151	9.04057	17.8508	NA	NA	NA	26.4	8.6	4.3
hg	10.4	0.019085	0.07931	0.187	NA	NA	NA	544.9	131.1	55.6
Mo	1.69	0.145387	0.8624	2.5212	NA	NA	NA	11.6	2.0	0.7
Ni	78	0.771254	4.01929	10.868	NA	NA	NA	101.1	19.4	7.2
Se	25.2	0.015906	0.09966	0.3014	NA	NA	NA	1,584.3	252.9	83.6
Zn	172	10.778174	41.87007	94.8464	NA	NA	NA	16.0	4.1	1.8
A/D	0.0164	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
BAP	0.134	0.000011	0.002574	0.076021	PASS	PASS	PASS			
CLD	1.2	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DDT	0.205	0.0000738	0.000364587	0.000959644	PASS	PASS	PASS			
HEPC	15.6	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
HXBE	16.8	0.00044	0.006193	0.030283	PASS	PASS	PASS			
HXBU	4810	0.001232	0.003432	0.006358	PASS	PASS	PASS			
LIN	73.2	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
PCB	0.201	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
TOX	0.0483	0.0000535	0.000324155	0.000959644	PASS	PASS	PASS			
DMN	0.039	0.003091	0.00858	0.015895	PASS	PASS	PASS			
TCE	0.00127	0.0058219	0.2221395	1.99342	FAIL	FAIL	FAIL			

Source: ERG estimates.

In Option 3, some POTWs were assumed able to comply with land application criteria if they composted their sludge. (The sludge contaminants are diluted during the composting process.) Analyses show that composted sludges of all types (typical, 90th and 98th percentile) do not meet either the annual agricultural or nonagricultural annual pollutant loading limits, although cumulative application limits approximately double.

Thus, all POTWs currently land applying sewage sludge (2,623 facilities), regardless of end use, are estimated to fail the Option 4 criteria. It is assumed that these POTWs must shift to alternative disposal practices to meet Option 4 criteria.

4.4.3.4 Numbers of POTWs that Fail Option 4 Criteria by End Use

As discussed earlier, 77 percent of land application is associated with agricultural end uses, while 10 percent is associated with the nonagricultural end uses of dedicated disposal and reclamation. Another 13 percent goes to end uses classified as "other," a category that primarily includes the miscellaneous nonagricultural end uses described previously.

Table 4-75 presents the numbers of POTWs distributed by end use, sludge type and size. A total of 2,020 POTWs practicing agricultural land application fail to meet the criteria. There are 603 POTWs practicing nonagricultural land application (which includes the "other" category of end uses). These POTWs also fail to meet the regulatory criteria. Several disposal options are available to these POTWs. As in Option 3, codisposal is assumed available to the smallest two size classes of POTWs. Incineration is assumed to be available to the larger POTWs. Additionally, distribution and marketing of composted sludge is a third option that may be chosen by POTWs currently practicing all types of land application. This option may be available to some POTWs generating typical sludges since, as the analysis in Section 4.4.4 will show, this sludge type passes the criteria for distribution and marketing. The costs of shifting to these alternative disposal practices are discussed below.

TABLE 4-75

DISTRIBUTION OF POTWs BY SLUDGE TYPE AND END USE

					NONAGRICULTURAL													
	AGRICULTURAL				DEDICATED				RECLAMATION				OTHER					
SIZE	TYPICAL	90th	98TH	SUB-TOTAL	TYPICAL	90TH	98TH	SUB-TOTAL	TYPICAL	90TH	98TH	SUB-TOTAL	TYPICAL	90TH	98TH	SUB-TOTAL	TOTAL NON-AGRI-CULTURAL	TOTAL LAND APPLI-CATION
0.1 MGD	791	29	4	824	72	3	0	75	31	1	0	32	134	5	1	140	247	1,071
0.5 MGD	603	65	16	684	55	6	1	62	23	3	1	27	102	11	3	116	205	889
2 MGD	325	111	19	455	29	10	2	41	13	4	1	18	55	19	3	77	136	591
14 MGD	32	16	3	51	3	1	0	4	1	1	0	2	5	3	0	8	14	65
128 MGD	3	3	0	6	0	0	0	0	0	0	0	0	1	0	0	1	1	7
TOTAL	1,754	224	42	2,020	159	20	3	182	68	9	2	79	297	38	7	342	603	2,623

Source: ERG estimates.

2121S

4.4.3.5 Compliance Costs

The compliance costs for land-applied sludge include the costs of shifting to alternative disposal practices and the costs of meeting management practice requirements for those POTWs shifting to distribution and marketing or incineration. The costs of shifting disposal practices, costs for sludge labeling and sludge monitoring, recordkeeping and reporting for those POTWs that shift to distribution and marketing, and costs for sludge monitoring, reporting and recordkeeping for those that shift to incineration will be estimated below.

Costs of Shifting to Alternative Disposal Practices

Agricultural Land Application. As noted above, all POTWs practicing agricultural land application are estimated to shift to alternative disposal methods. Shifting costs estimated for these POTWs have been divided into those for POTWs generating typical sludges (in Table 4-76) and those for POTWs generating 90th and 98th percentile sludges (in Table 4-77). The 1,754 POTWs generating typical sludges that currently practice agricultural land application are estimated to be able to shift to codisposal in municipal landfills, to distribution and marketing, or to incineration. As discussed previously, only the two smallest size groups of POTWs are assumed to be able to shift to codisposal because of the widespread problems with landfill capacity in many areas of the country (see Section Three). The POTWs in the three largest size classes are assumed to be able to choose between incineration and distribution and marketing, based on which disposal method is the most cost-effective choice. It is estimated that all these larger size POTWs will choose to shift to distribution and marketing, since this method is the least expensive choice for POTWs in these size classes.

POTWs generating 90th and 98th percentile sludges do not have the option of choosing distribution and marketing since these sludges fail to meet the distribution and marketing criteria. POTWs generating these sludge types are assumed to choose codisposal (0.1- and 0.5-MGD facilities) or incineration (all other facilities). Note that incineration costs include the costs of meeting Option 3 incineration criteria.

TABLE 4-76

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS CURRENTLY PRACTICING AGRICULTURAL LAND APPLICATION WITH TYPICAL SLUDGES UNDER OPTION 4

($1987)

SIZE	NO. OF POTWS WITH TYPICAL SLUDGES	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	791	Codisposal	$102	$ 1,775,004
0.5 MGD	603	Codisposal	111	7,429,563
2 MGD	325	Distribution and Marketing	150	21,693,750
14 MGD	32	Distribution and Marketing	117	11,666,304
128 MGD	3	Distribution and Marketing	105	8,970,570
Total	1,754			$51,535,191

Source: ERG estimates.

2107S

TABLE 4-77

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS CURRENTLY PRACTICING AGRICULTURAL LAND APPLICATION WITH 90TH AND 98TH PERCENTILE SLUDGES UNDER OPTION 4

($1987)

SIZE	NO. OF POTWS WITH 90TH AND 98TH PERCENTILE SLUDGES	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	33	Codisposal	$ 102	$ 74,052
0.5 MGD	81	Codisposal	111	998,001
2 MGD	130	Incineration	1,000	57,850,000
14 MGD	19	Incineration	439	25,990,556
128 MGD	3	Incineration	151	12,900,534
Total	266			$97,813,143

Source: ERG estimates.

POTWs that are estimated to shift to distribution and marketing must meet the pathogen reduction requirements of the Option 4 regulation. Composting has been estimated to achieve the pathogen reduction requirements. Additionally, it is assumed that composted sludge will be used by the same consumers of the currently available noncomposted sludge so that no costs (such as for market development), other than those for composting, are incurred. Further, it is assumed that the POTW no longer applies the sludge itself, but distributes the composted sludge to farmers. The incremental cost is thus the difference between the costs of land application and the costs of composting.

The total annual incremental costs associated with shifts in disposal practices for POTWs generating typical sludges are $51.5 million (see Table 4-76). For POTWs generating 90th and 98th percentile sludges, these costs total $97.8 million annually. Annual incremental costs for shifting disposal practices for all POTWs practicing agricultural land application are $149.3 million.

Nonagricultural Land Application. Those POTWs practicing dedicated disposal or reclamation regardless of sludge quality are estimated to shift to codisposal or incineration (see Tables 4-78 and 4-79). These POTWs are assumed to be unable to choose the distribution and marketing option since it requires establishing a new market for sludge that is not necessarily available. The costs of this shift are $23.8 million for all POTWs practicing dedicated disposal. For POTWs practicing reclamation, a total incremental cost of $22.8 million is incurred for shifting to alternative disposal practices. Note that the two smallest size classes of POTWs practicing reclamation are assumed to incinerate their sludge. Codisposal is a less expensive option than reclamation, so it is assumed that POTWs that have chosen reclamation rather than codisposal do not have a municipal landfill disposal option available to them.

The cost of incineration at the smallest facilities has been derived somewhat differently than the costs of incineration at other size facilities. If a 0.1-MGD facility were to build an onsite incinerator, it has been estimated that sludge disposal would cost $11,387 per dry metric ton without pollution controls (see baseline costs of disposal, Section Three). No POTW in this size class currently operates an incinerator. It is thus considered unlikely that many POTWs of this size would elect to construct onsite incinerators. It may be possible for some POTWs to transport their sludge to offsite incinerators willing to take the small amount of sludge generated by these POTWs. Since the availability of offsite incinerators is not known, the cost per DMT used in calculating the incremental costs of shifting to incineration at these smallest facilities has been derived as the midpoint between the cost of building an onsite incinerator and the cost of transporting to a larger offsite incinerator (assumed to be an incinerator associated with a 2-MGD facility with shipping costs of $131/DMT - see baseline costs of transportation developed for transporting sludge to municipal landfills in Section Three), or $8,369/DMT. Total pollution control costs for the onsite facility are assumed the same as those for 0.5-MGD size facilities, since control equipment costs were not estimated for incinerators serving POTWs of the 0.1-MGD size class. The incremental costs of incineration in this size facility are thus estimated to be $7,733/DMT (the cost of incinerating sludge minus the cost of using sludge in land reclamation). POTWs in the 0.5-MGD size class are assumed to construct an onsite incinerator, since POTWs of this size currently operate onsite incinerators. This cost is incorporated in Table 4-86, which shows the estimated total costs of POTWs shifting from land reclamation to incineration of $22.9 million.

POTWs that currently dispose of their sludge through "other" end uses must also shift to alternative disposal practices regardless of sludge quality. These POTWs are assumed to choose among the same options as those available to agricultural land appliers (codisposal, distribution and marketing and incineration). The distribution and marketing option is available only to POTWs generating typical sludges, and this option is estimated to be chosen by all of the larger POTWs with typical sludges. Those POTWs generating 90th and 98th percentile sludges are limited to either codisposal or incineration. Among the POTWs generating typical sludges, the shift to distribution and marketing is estimated to require no substantive change in the end use of the

TABLE 4-78

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING DEDICATED DISPOSAL UNDER OPTION 4

($1987)

SIZE	NO. OF POTWs	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	75	Codisposal	$ 61	$ 100,650
0.5 MGD	62	Codisposal	94	646,908
2 MGD	41	Incineration	971	17,715,895
14 MGD	4	Incineration	428	5,334,592
128 MGD	0	Incineration	151	0
Total	182			$23,798,045

Source: ERG estimates.

TABLE 4-79

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING RECLAMATION UNDER OPTION 4

($1987)

SIZE	NO. OF POTWs	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	32	Incineration	$7,733	$ 5,444,032
0.5 MGD	27	Incineration	2,868	8,595,396
2 MGD	18	Incineration	864	6,920,640
14 MGD	2	Incineration	312	1,944,384
128 MGD	0	Incineration	32	0
Total	79			$22,904,452

Source: ERG estimates.

sludge. Also, since POTWs practicing "other" disposal methods are not assumed to land apply their own sludge (a negligible baseline cost is estimated for those POTWs), the incremental costs of shifting to distribution and marketing includes the cost of composting only. Tables 4-80 and 4-81 present the costs of shifting to alternative practices for POTWs with typical sludges and 90th and 98th percentile sludges, respectively. The total annual incremental costs for the POTWs associated with "other" end uses that shift to alternative disposal practices are $19.0 million for typical sludges and $16.5 million for 90th and 98th percentile sludges, for a total of $35.5 million annually.

The total annual incremental costs for shifting disposal practices for all POTWs practicing nonagricultural land application that fail to meet the relevant criteria are $82.2 million.

Labeling Costs

POTWs shifting to distribution and marketing will have to label their sludges or provide a handout when the sludge is distributed. Bagged sludge must be labeled and bulk sludge must be accompanied with a handout. Both labels and handouts must include the name and address of distributor; a statement that the product contains sewage sludge; a prohibition against using the product on frozen; flooded, or snow-covered land, instructions on the use of the product; including the annual product application rate; and a warning to keep the product out of reach of children until incorporated into the soil. The cost of labeling has been derived previously and totals $324 per POTW. A total of 421 POTWs are estimated to shift to distribution and marketing for a total of $136,404 in annual labeling costs.

Sludge Monitoring, Recordkeeping and Reporting Costs

All POTWs that do not shift to codisposal will incur sludge testing costs. POTWs shifting to incineration will incur the costs of testing for seven metals; those shifting to distribution and marketing will incur the cost of testing nine metals and organics. The frequency of testing is once per

TABLE 4-80

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING "OTHER" LAND APPLICATION DISPOSAL WITH TYPICAL SLUDGES UNDER OPTION 4

($1987)

SIZE	NO. OF POTWs WITH TYPICAL SLUDGE	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	134	Codisposal	$ 340	$ 1,002,320
0.5 MGD	102	Codisposal	290	3,283,380
2 MGD	55	Distribution and Marketing	326	7,978,850
14 MGD	5	Distribution and Marketing	163	2,539,540
128 MGD	1	Distribution and Marketing	147	4,186,266
Total	297			$18,990,356

Source: ERG estimates.

TABLE 4-81

ANNUAL COSTS OF SHIFTING TO ALTERNATIVE DISPOSAL PRACTICES FOR POTWS PRACTICING "OTHER" LAND APPLICATION DISPOSAL WITH 90TH AND 98TH PERCENTILE SLUDGES UNDER OPTION 4

($1987)

SIZE	NO. OF POTWs WITH 90TH AND 98TH PERCENTILE SLUDGE	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	6	Codisposal	$ 340	$ 44,880
0.5 MGD	14	Codisposal	290	450,660
2 MGD	22	Incineration	1,176	11,513,040
14 MGD	3	Incineration	485	4,533,780
128 MGD	0	Incineration	193	0
Total	45			$16,542,360

Source: ERG estimates.

2128S

year for POTWs processing less than 1 MGD wastewater, quarterly for POTWs processing 1 to 10 MGD, and once per month for POTWs processing more than 10 MGD. It is assumed that all the costs of sludge testing are incremental to baseline costs, as discussed in Section 4.2.2.2.

The POTWs that shift to distribution and marketing are assumed to compost their sludges to meet pathogen reduction requirements. Therefore, the costs for testing composted sludges have been used: $18 per metal and $823 for all organics. The costs for testing incinerated sludges are $15 per metal. Costs for pathogen testing are assumed to be $100/test. The incremental testing costs are presented in Table 4-82. The total annual cost of sludge testing for these POTWs is $2.3 million.

Recordkeeping and reporting costs will also be incurred. As noted in previous sections, it is estimated that recordkeeping costs are $525/POTW annually. Reporting costs are estimated at $150/POTW/reporting period. Total recordkeeping costs are $379,050 and total reporting costs are $493,050. Contract costs must also be incurred. All POTWs shifting to distribution and marketing are assumed to be required and able to write contracts at a cost of $324 annually per POTW for a total cost of $136,404. Also, for POTWs shifting to incineration, costs for performance tests and air dispersion modeling ($3.9 million) and for continuous monitoring and recording of incinerator operating conditions ($15.4 million) are incurred.

Total costs for sludge testing, contracts, recordkeeping and reporting are $12.6 million (see Table 4-82).

Summary of Compliance Costs

Table 4-83 summarizes the estimated compliance costs associated with shifts in disposal practices, labeling, sludge testing, recordkeeping and reporting. The total first-year incremental costs for POTWs using agricultural and nonagricultural land application are $244.3 million. In subsequent years these costs are $240.4 million.

TABLE 4-82

ANNUAL SLUDGE TESTING, RECORDKEEPING, AND REPORTING COSTS FOR POTWS SHIFTING TO DISTRIBUTION AND MARKETING AND INCINERATION UNDER OPTION 4

($ 1987)

SIZE	NO. OF POTWS SHIFTING TO DISTRIBUTION AND MARKETING	NO. OF POTWS SHIFTING TO INCINERATION	TESTING REQUIREMENTS	COST OF TESTING/YR FOR COMPOSTED SLUDGE[a]	COST OF TESTING/YR FOR INCINERATED SLUDGE[b]	PERFORMANCE TESTING AND AIR DISPERSION MODELING	CONTINUOUS MONITORING AND RECORDING COSTS	RECORD-KEEPING COSTS	CONTRACT COSTS	REPORTING COSTS	TOTAL COSTS OF TESTING[c]
0.1 MGD	0	32	1/yr	$ 0	$ 3,360	$ 410,592	$ 578,240	$ 16,800	$ 0	$ 4,800	$ 1,013,792
0.5 MGD	0	27	1/yr	0	2,835	346,437	487,890	14,175	0	4,050	855,387
2 MGD	380	211	4/yr	1,649,200	88,620	2,707,341	3,812,770	310,275	123,120	354,600	9,045,926
14 MGD	37	28	1/mo	481,740	35,280	359,268	505,960	34,125	11,988	117,000	1,545,361
128 MGD	4	3	1/mo	52,080	3,780	38,493	54,210	3,675	1,296	12,600	166,134
TOTAL	421	301		$2,183,020	$133,875	$3,862,131	$5,439,070	$379,050	$136,404	$493,050	$12,626,600

[a] Costs of testing for organics, nine metals and pathogens in composted sludge.

[b] Costs of testing for seven metals.

[c] These are first-year costs. Costs in subsequent years are $8,764,469.

Source: ERG estimates.

TABLE 4-83

TOTAL ANNUAL COMPLIANCE COSTS FOR POTWS PRACTICING LAND APPLICATION UNDER OPTION 4

($1987)

	COSTS OF SHIFTING PRACTICES						
SIZE	AGRICULTURAL	DEDICATED DISPOSAL	RECLAMATION	OTHER	LABELING COSTS	MONITORING RECORD-KEEPING AND REPORTING COSTS	COMPLIANCE COSTS[a]
0.1 MGD	$ 1,849,056	$ 100,650	$ 5,372,224	$ 1,047,200	$ 0	$1,013,792	$ 9,382,922
0.5 MGD	8,427,564	646,908	8,592,399	3,734,040	0	855,387	22,256,298
2 MGD	79,543,750	17,715,895	6,920,640	19,491,890	123,120	9,045,926	132,841,221
14 MGD	37,656,860	5,334,592	1,944,384	7,073,320	11,988	1,545,361	53,566,505
128 MGD	21,871,104	0	0	4,186,266	1,296	166,134	26,224,800
TOTAL	$149,348,334	$23,798,045	$22,829,647	$35,532,716	$136,404	$12,626,600	$244,271,746

[a] These are first-year costs. Costs in subsequent years are $240,409,615.

Source: ERG estimates.

2113S

Total residents served by POTWs using land application number 29.2 million. Assuming three persons per household, total incremental costs can be expressed on a per-household basis: $25.10 per household per year (first-year costs). In subsequent years, these costs are $24.71. In addition to the residential population, commercial and industrial customers are also part of the total population served. The incremental costs, therefore, would be spread over all customers and the actual per-household increment would be reduced.

4.4.4 Costs and Impacts of Regulatory Option 4 Governing the Distribution and Marketing of Sewage Sludge

This section discusses the impacts of Option 4 requirements on the distribution and marketing of sewage sludge.

4.4.4.1 Overview of Option 4 Requirements

Option 4 defines maximum pollutant loading limits for the distributed and marketed sludges. The level of contaminants in and the application rate of the sludge defines the pollutant loading rate of sludge contaminants. This loading rate must not exceed the maximum pollutant loading limit established by the risk assessment. Both annual and cumulative limits are defined for Option 4; under Option 3, only annual limits applied.

The frequency of sludge testing and reporting is dependent on the size of the POTW: sludge must be tested and reports prepared once per year at POTWs processing less than 1 MGD; once per quarter at POTWs processing between 1 and 10 MGD; and once per month at POTWs processing more than 10 MGD. Recordkeeping tasks are the same as those required under Option 3.

Distribution and marketing management practices are also specified in Option 4 requirements. Bagged sludge must be labeled and bulk sludge must be accompanied with a handout. Both labels and handouts must include the name and address of distributor; a statement that the product contains sewage sludge; a prohibition against using the product on frozen, flooded, or snow-covered land; instructions on the use of the product, including the annual product application rate; and a warning to keep the product out of reach of children until incorporated into the soil.

The regulation also requires that the sludge meet Class A pathogen/vector attraction reduction requirements. Class A pathogen reduction is the highest (i.e., most stringent) level of control specified for sludge, as discussed in Section 4.3.3.

4.4.4.2 Methodology

The contaminants in the composted sludge quality profiles (typical, 90th and 98th percentile sludges) have been calculated based on the same dilution factor discussed in Section 4.3.4.2. The final concentrations of pollutants in the composted sludge for each of the sludge quality profiles are then used with the assumed application rate of 11 DMT/ha to produce a pollutant loading rate. This pollutant loading rate is then compared to the maximum pollutant loading limit specified by Option 4 for each contaminant of concern. If the loading rate of a contaminant exceeds the limit, a "fail" is specified for the contaminant. If one contaminant in the sludge fails to meet the criteria for that pollutant, the sludge profile fails to meet the Option 4 criteria. Cumulative pollutant loadings are also specified. It is assumed that if the sludge can be applied once to a unit of land it passes the cumulative pollutant loading criteria.

When the number of POTWs that fail to meet Option 4 criteria is determined, the costs of shifting to alternative disposal practices are estimated. Costs for meeting management practice requirements are also estimated for those POTWs that meet the Option 4 criteria.

4.4.4.3 Results

The results of the application rate analysis are presented in Table 4-84. According to this analysis, typical sludges can be applied at the typical application rate of 11 DMT per hectare and meet the annual pollutant loading limits. The cumulative limit for typical sludge is 22 applications, defined by the limit for copper. At the 11 DMT/ha application rate, 90th and 98th percentile sludges fail to meet the criteria. These sludges would have to be applied at less than 3 DMT/ha. The cumulative limits for these sludges are six applications and two applications, respectively.

4.4.4.4 Numbers of Affected POTWs

The number of POTWs practicing distribution and marketing could not be directly determined using the current data base. For purposes of this analysis, composted sludge was used as a proxy for distributed and marketed sludge. Thus, POTWs known to compost sewage sludge and the quantities of sludge known to be composted were used to approximate the number of POTWs and volumes of sludge involved in distribution and marketing.

The 35 POTWs generating 90th and 98th percentile sludge disposed of through distribution and marketing are assumed to shift to alternative disposal practices. The costs of shifting to alternative disposal practices are discussed below for those POTWs that fail the criteria, along with management practice costs for POTWs that are estimated to meet the criteria and thus do not shift to alternative disposal practices.

4.4.4.5 Compliance Costs

Compliance costs for POTWs that practice distribution and marketing of sewage sludge include management practice costs and costs of shifting to alternative disposal methods. Each of these cost categories is discussed below.

TABLE 4-84. PASS/FAIL ANALYSIS FOR DISTRIBUTION AND MARKETING UNDER OPTION 4

Pollutant	MAX CUMUL. RATE (KG/HA)	MAX APPL RATE (KG/HA)	METRIC TONS PER HA			ANNUAL POLLUTANT LOADING PASS/FAIL			CUMULATIVE POLLUTANT LOADING NUMBER OF YEARS OF APPLICATION		
			11	11	11						
			TYPICAL (kg/ha)	90th PERC. (kg/ha)	98 PERC. (kg/ha)	TYPICAL	90th PERC.	98th PERC.	TYPICAL	90th PERC.	98th PERC.
As	14	0.7	0.0215660	0.081089178	0.180088229	PASS	PASS	PASS	649.2	172.6	77.7
Cd	16.9	0.845	0.0553573	0.503257546	1.902800357	PASS	PASS	FAIL	305.3	33.6	8.9
Cr	200	10	1.2277861	5.890666192	15.15412765	PASS	PASS	FAIL	162.9	34.0	13.2
Cu	46	2.3	2.0334137	7.460501224	16.32816437	PASS	FAIL	FAIL	22.6	6.2	2.8
Pb	77.3	3.865	1.3147479	4.066184424	8.028768642	PASS	FAIL	FAIL	58.8	19.0	9.6
Hg	39.8	1.99	0.0085838	0.035671322	0.084107140	PASS	PASS	PASS	4,636.6	1,115.7	473.2
Ni	78	3.9	0.3468875	1.807759289	4.888109082	PASS	PASS	FAIL	224.9	43.1	16.0
Se	162	8.1	0.0071540	0.044824158	0.135560919	PASS	PASS	PASS	22,644.5	3,614.1	1,195.0
Zn	172	8.6	4.8477079	18.83193498	42.65914145	PASS	FAIL	FAIL	35.5	9.1	4.0
A/D		0.00068	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
BAP		0.0077	0.0000049	0.00115771	0.034192026	PASS	PASS	FAIL			
CLD		0.955	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
DDT		0.000462	0.0000332	0.000163980	0.00043162	PASS	PASS	PASS			
HEPC		0.000788	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
HXBE		0.000267	0.0001978	0.002785430	0.013620409	PASS	FAIL	FAIL			
HXBU		0.408	0.0005541	0.001543613	0.002859642	PASS	PASS	PASS			
LIN		989	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
PCB		0.0046	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
TOX		0.00117	0.0000240	0.000145795	0.00043162	PASS	PASS	PASS			
DMN		118000	0.0013902	0.003859033	0.007149106	PASS	PASS	PASS			

Source: ESource: ERG estimates.

Management Practice Costs

Management practice costs include the costs of preparing labels and handouts for distributed sludge, testing the sewage sludge, performing recordkeeping and reporting tasks, reducing application rates, and meeting pathogen reduction requirements. These costs are discussed below.

Labeling and Handout Development. The POTW must develop and distribute a handout to users of the composted or heat treated sludge. Bagged sludge products must have labels with the same printed information. The name and address of the producer, a description of the product, recommended soil pH, instructions for proper use of the product, plant nutrient values, and several prohibitions must be included in the handout or on the label. As discussed before, the costs for labeling and handout development are $324/POTW. Total labeling costs of $23,004 will thus be incurred by the 71 POTWs generating typical sludges.

Pathogen and Vector Attraction Reduction. Sludges that are distributed and marketed must meet Class A pathogen and vector attraction reduction requirements. This level of reduction is assumed to be achieved when sewage sludge is properly composted. No incremental costs associated with meeting Class A Pathogen and Vector Attraction Reduction requirements are incurred.

Reduction of Application Rates. As the results of the pass/fail analysis show, typical sludge can pass the criteria, as long as application rates are at 11 DMT/ha. POTWs generating 90th and 98th percentile sludges are assumed to shift to alternative disposal methods rather than trying to reduce their application rates (see discussion in Section 4.3.4.4). No costs are estimated for this item.

Sludge Monitoring, Recordkeeping and Reporting. All POTWs will incur testing costs, since all either continue with distribution and marketing or shift to incineration. Yearly sludge testing for small POTWs, quarterly testing for mid-size POTWs and monthly testing for large POTWs must be performed. Existing state regulations require some testing, but not at the same frequency or for all the pollutants covered by the regulations. It is thus assumed that all testing costs are incremental. Testing costs for metals in composted sludges are estimated at $15 or $18 per metal depending on whether the sludge is noncomposted or composted, respectively; testing costs for all organics are $823. Pathogen testing costs of $100/test are also incurred by POTWs that continue to distribute and market their sludge. Recordkeeping costs of $525 per POTW and reporting costs of $150/POTW/reporting period are incurred by all 106 POTWs. Contract costs are also incurred by POTWs that continue to distribute and market their sludge. It is assumed that all of these POTWs but the 13 percent estimated to provide sludge directly to consumers (10 POTWs) can write these contracts (see discussion in 4.3.4) at a cost of $324/POTW for a total cost of $19,764. Total costs of testing, recordkeeping and reporting are $2.8 million, as shown in Table 4-85.

Shifts in Disposal Practice

As discussed above in Section 4.4.4.4, 35 POTWs generating 90th and 98th percentile sludges fail to meet Option 4 criteria. These POTWs are assumed to shift to alternative disposal methods. Codisposal is not considered to be available to POTWs practicing composting. It is assumed that these POTWS would have already chosen codisposal over the more expensive composting alternative, if they could. Thus all POTWs that fail to meet the distribution and marketing criteria are assumed to shift to incineration. The smallest POTWs are assumed to either build onsite incinerators or ship their sludge offsite to a larger incinerator. The midpoint of these costs has been assumed in calculating the incremental costs of incinerating sludges at these smallest facilities (see discussion in Section 4.4.3.5).

The costs of shifting to alternative disposal practices are presented in Table 4-86. As the table shows, the compliance costs associated with shifts in disposal practices for these POTWs are $22.6 million.

TABLE 4-85

COSTS OF SLUDGE TESTING, RECORDKEEPING, AND REPORTING FOR POTWS PRACTICING DISTRIBUTION AND MARKETING

($ 1987)

SIZE	NO. OF POTWS PRACTICING DISTRIBUTION AND MARKETING	NO. OF POTWS SHIFTING TO INCIN-ERATION	FREQUENCY OF TESTING	COST/YR COMPOSTED SLUDGE[a]	COST/YR INCIN-ERATED SLUDGE[b]	PERFORMANCE TESTING AND AIR DISPERSION MODELING	RECORD-KEEPING COSTS	CONTRACT COSTS	CONTINUOUS MONITORING AND RECORDING	REPORTING COSTS	TOTAL COST[c]
0.1 MGD	4	1	1/yr	$ 4,340	$ 105	$ 12,831	$ 2,625	$ 972	$ 18,070	$ 750	$ 39,693
0.5 MGD	21	6	1/yr	22,785	630	76,986	14,175	5,832	108,420	4,050	232,878
2 MGD	30	15	4/yr	1,302,000	6,300	192,465	23,625	8,424	271,050	27,000	1,830,864
14 MGD	9	7	1/mo	117,180	8,820	89,817	8,400	2,592	126,490	28,800	382,099
128 MGD	7	6	1/mo	91,140	7,560	76,986	6,825	1,944	108,420	23,400	316,275
TOTAL	71	35		$1,537,445	$23,415	$449,095	$55,650	$19,764	$632,450	$84,000	$2,801,809

[a] Costs of testing organics, nine metals and pathogens in composted sludge.

[b] Costs of testing seven metals in noncomposted sludge.

[c] Total costs are first-year costs. Costs in subsequent years are $2,352,724.

Source: ERG estimates.

TABLE 4-86

COSTS OF SHIFTING DISPOSAL PRACTICES FOR POTWS PRACTICING DISTRIBUTION AND MARKETING

($ 1987)

SIZE	NO. OF POTWs	ALTERNATIVE DISPOSAL PRACTICE	INCREMENTAL COST/DMT	TOTAL SHIFTING COSTS
0.1 MGD	1	Incineration	$7,556	$ 166,232
0.5 MGD	6	Incineration	2,766	1,842,156
2 MGD	15	Incineration	850	5,673,750
14 MGD	7	Incineration	322	7,023,464
128 MGD	6	Incineration	46	7,859,928
Total	35			$22,565,530

Source: ERG estimates.

Summary of Compliance Costs

Table 4-87 summarizes the estimated compliance costs associated with sludge testing, recordkeeping and reporting, labeling and shifts in disposal practices. The total first-year incremental costs for POTWs using distribution and marketing are $25.4 million. In subsequent years, these costs total $24.9 million.

Total residents served by POTWs using distribution and marketing end uses number 16.3 million. Assuming three persons per household, total incremental costs can be expressed as $4.68 per household per year (first year) for POTWs using distribution and marketing. In subsequent years, this cost is $4.60. In addition to the residential population, commercial and industrial customers are also a part of the total population served. The incremental costs, therefore, would be spread over all customers and the actual per-household increment would be reduced.

4.4.5 Summary of Option 4 Compliance Costs

Option 4 compliance costs are presented in Table 4-88. Total compliance costs are $399.0 million. The majority of these compliance costs are associated with land application ($244.3 million). Incineration, at $103.8 million, is associated with the next largest portion of compliance costs. Monofills and distribution and marketing are associated with compliance costs of $25.5 million and $25.4 million, respectively. Note that the $399.0 million total represents first-year costs, since incinerator emission testing and dispersion modeling costs are one-time costs. In subsequent years these costs are $396.4 million.

4.5 Summary and Comparison of Annual Compliance Costs Under the Four Regulatory Options

Table 4-89 presents a summary of total costs for all four regulatory options. Total annual compliance costs range from $27.6 million under Option

TABLE 4-87

TOTAL ANNUAL COMPLIANCE COSTS FOR ALL POTWS PRACTICING DISTRIBUTION AND MARKETING UNDER OPTION 4

($ 1987)

SIZE	SHIFTING COSTS	MONITORING, RECORDKEEPING AND REPORTING COSTS	LABELING COSTS	TOTAL[a]
0.1 MGD	$ 166,232	$ 39,693	$ 1,296	$ 207,221
0.5 MGD	1,842,156	232,878	6,804	2,081,838
2 MGD	5,673,750	1,830,864	9,720	7,514,334
14 MGD	7,023,464	382,099	2,916	7,408,479
128 MGD	7,859,928	316,275	2,268	8,178,471
Total	$22,565,530	$2,801,809	$23,004	$25,390,343

[a] First-year costs. Costs in subsequent years are $24,941,258.

Source: ERG estimates.

TABLE 4-88

SUMMARY OF TOTAL COMPLIANCE COSTS UNDER OPTION 4
($ 1987)

SIZE	INCINERATION	MONOFILL	LAND APPLICATION	DISTRIBUTION AND MARKETING	TOTAL[a]
0.1 MGD	$ 0	$ 4,290	$ 9,382,922	$ 207,221	$ 9,594,433
0.5 MGD	371,757	166,278	22,256,298	2,081,838	24,876,171
2 MGD	9,989,728	8,488,079	132,841,221	7,514,334	158,833,362
14 MGD	23,429,960	12,871,180	53,566,505	7,408,479	97,276,124
128 MGD	70,013,892	3,964,450	26,224,800	8,178,471	108,381,613
Total	$103,805,337	$25,494,277	$ 244,271,746	$25,390,343	$398,961,703

[a] This total represents first-year costs, since costs for incinerator emissions testing and dispersion modeling are one-time costs. In subsequent years costs are $396,397,764.

Source: ERG estimates.

TABLE 4-89

SUMMARY OF TOTAL INCREMENTAL COSTS: OPTIONS 1 THROUGH 4[a]

($ 1987)

SIZE	OPTION 1	OPTION 2	OPTION 3	OPTION 4
0.1 MGD	$ 852,393	$ 930,909	$ 4,887,198	$ 9,594,433
0.5 MGD	762,468	1,136,785	3,860,082	24,876,171
2 MGD	4,772,316	9,311,196	29,525,142	158,833,362
14 MGD	10,585,489	12,180,745	42,332,632	97,276,124
128 MGD	10,656,082	10,674,118	76,950,625	108,381,613
Total	$27,628,748	$34,283,753	$157,555,679	$398,961,703

[a] First-year costs only.

Source: ERG estimates.

1 to $378.6 million under Option 4. Option 3, the selected regulatory option, is estimated to be associated with annual compliance costs totaling $157.6 million.

Table 4-90 shows that the total costs for Option 3 are $123.4 million more than those for Option 2 and $97.9 million more than those for Option 1 ($123.4 million plus the $6.6 million difference between Option 1 and Option 2). Option 3 costs are, however, $241.4 million less than those for Option 4.

4.6 Impacts to Small Entities

This section addresses the effects of the proposed regulations on small entities. The Regulatory Flexibility Act requires all federal agencies to separately analyze the impacts of proposed regulations on small businesses, small governmental jurisdictions, and small organizations. The purpose of this analysis is to determine whether the proposed regulatory action will have a significant impact on a substantial number of small entities.

In the context of the proposed sludge disposal regulations, small POTWs are considered small entities. The daily influent flow the facility is designed to treat, expressed in millions of gallons per day of wastewater (MGD), is one parameter commonly used to measure the size of a POTW. In this regulatory impact analysis, five model POTW sizes, representing groups of POTWs processing an average of 0.1 MGD, 0.5 MGD, 2 MGD, 14 MGD, and 128 MGD of wastewater, have been used in the development of economic impacts. Ninety-two percent of POTWs covered by the proposed regulations are in the 0.1-MGD, 0.5-MGD and 2-MGD size classes. About two-thirds of all POTWs are in the two smallest size categories.

Table 4-91 presents the distribution of POTWs in the five size classes by disposal option. The total number of POTWs in the two smallest size categories (0.1 and 0.5 MGD) that are expected to incur costs as a result of the proposed regulations is 4,342. This represents 28 percent of the total number of POTWs, including those using codisposal and other disposal practices

TABLE 4-90

INCREMENTAL COST DIFFERENCES BETWEEN OPTIONS
($1987)

	INCREASE IN COMPLIANCE COST		
SIZE	OPTION 1 TO OPTION 2	OPTION 2 TO OPTION 3	OPTION 3 TO OPTION 4
0.1 MGD	$ 78,516	$3,956,289	$4,707,235
0.5 MGD	424,317	2,673,297	21,016,089
2 MGD	4,538,880	20,337,550	129,308,220
14 MGD	1,595,256	30,182,788	54,943,492
128 MGD	18,036	66,276,507	31,430,988
Total	$6,655,005	$123,426,431	$241,406,024

Source: ERG estimates.

2081S

TABLE 4-91

NUMBERS OF POTWS BY SIZE CLASS AND DISPOSAL OPTION

SIZE	INCINERATION	OCEAN[a]	MONOFILL	LAND APPLICA-CATION	DISTRI-BUTION AND MARKET-ING	SURFACE IMPOUND-MENTS	TOTAL	PERCENT OF TOTAL
0.1 MGD	0	0	5	1,071	5	1,968	3,049	57%
0.5 MGD	3	2	14	889	27	358	1,293	24%
2 MGD	71	3	19	591	45	59	788	15%
14 MGD	76	6	10	65	16	9	182	3%
128 MGD	19	14	1	7	13	1	55	1%
Total	169	25	49	2,623	106	2,395	5,367	100%

[a] Assumed to incinerate sludge due to legislation banning ocean disposal of sewage sludge.

Source: ERG estimates.

TABLE 4-92

IMPACTS TO SMALL ENTITIES
($ 1987)

	SMALL ENTITIES (POTWs < 1 MGD)	OTHERS	TOTAL	% OF TOTAL ATTRIBUTABLE TO SMALL ENTITIES
Option 1	$1,614,861	$26,013,887	$27,628,748	5.8%
Option 2	2,117,694	32,166,059	34,283,753	6.2%
Option 3	8,747,280	148,962,904	157,555,679	5.6%
Option 4	34,470,604	364,491,099	398,961,703	8.6%

Source: ERG estimates.

2079S

not regulated by the proposed regulations. Among the POTWs covered by the regulation, the majority (93 percent) of these small entities practice land application or use surface impoundments. POTWs in this category will not incur significant compliance costs if their sludge is considered to be of typical quality (see Sections 4.3.3 and 4.3.5).

The compliance costs for the smallest two sizes of POTWs using each disposal method are compared to total compliance costs for all POTWs in Table 4-92 for Regulatory Options 1 through 4. Compliance costs for the two smallest size POTWs are about 6 percent of total costs for all the regulatory options, except for Option 4 where total costs for small entities are about 9 percent of total compliance costs; small entities have the smallest share of total costs under Option 3. In Option 3, most of the incremental costs incurred by these two smallest classes of POTWs are for annual sludge testing, recordkeeping and reporting. Sludge testing and reporting requirements have been designed to be a limited burden to these smaller facilities. Where larger POTWs are required to test and report quarterly or monthly, the smallest facilities are required only to test and report yearly. Thus, the impact of sludge testing and reporting, two of the major impacts on small POTWs, has been made as small as feasible without significantly affecting the ability of the regulation to protect human health and the environment.

Table 4-93 provides a more detailed breakdown of the compliance costs associated with the selected regulatory option, Option 3, for the smallest POTWs. Those plants using land application and surface impoundments incur the majority of the compliance costs for POTWs processing under 1 MGD. These POTWs make up 75 percent of all plants using land application and 97 percent of all plants using surface impoundments, but incur only 25 percent and 70 percent of the Option 3 land application and surface impoundment compliance costs. Thus, the smallest plants using land application and surface impoundments will incur a significant portion of the cost, but will not incur a greater proportion of the cost than their proportion in the population of POTWs. The average cost per POTW for compliance with land application rules is $1,697/year for 0.1-MGD facilities and $2,165 for 0.5-MGD facilities. The average cost per POTW for compliance with surface impoundment rules is

TABLE 4-93

BREAKDOWN OF COMPLIANCE COSTS IN THE TWO SMALLEST SIZE CLASS POTWS UNDER REGULATORY OPTION 3

($ 1987)

SIZE	INCINERATION	MONOFILL	LAND APPLICA-CATION	DISTRI-BUTION AND MARKET-ING	SURFACE IMPOUND-MENTS	TOTAL
0.1 MGD	$ 0	$ 4,290	$ 1,817,768	$ 11,716	$3,053,424	$ 4,887,198
0.5 MGD	$ 371,757	$ 166,278	$ 1,924,787	$ 735,346	$ 661,914	$ 3,860,082
Total, Small Entity	$ 371,757	$ 170,568	$ 3,742,555	$ 747,062	$3,715,338	$ 8,747,280
Total Compliance Costs, All POTWs	$103,885,337	$25,494,277	$15,163,286	$7,796,504	$5,296,275	$157,555,679
% of Total Attributable to Small Entities	0.4%	0.7%	24.7%	9.6%	70.2%	5.6%

Source: ERG estimates.

2077S

$1,552/POTW for 0.1-MGD facilities and $1,849/POTW for 0.5-MGD facilities. Total annual compliance costs averaged over all disposal practices are $1,603/year for 0.1-MGD facilities and $2,985/year for 0.5-MGD facilities.

Additionally, these smallest POTWs covered by the regulation service 2.5 million residents (0.1-MGD facilities) and 5.2 million residents (0.5-MGD facilities). The total average annual incremental per-household cost for residents serviced by POTWs in these size classes are $5.92 and $2.23, associated with 0.1-MGD and 0.5-MGD facilities, respectively. In comparison, populations served by 2-MGD, 14-MGD and 128-MGD facilities will incur average annual incremental per-household costs of $5.36, $5.29, and $5.78, respectively. Given that the incremental per-household costs associated with these smallest POTWs are about the same or less than those for the larger POTWs, impact on small entities is not considered excessive under Option 3, the chosen regulatory option.

It is thus concluded, following this analysis, that a substantial number of small entities will incur no significant impact as a result of the requirements of the proposed Option 3 sewage sludge regulation.

NOTES TO SECTION FOUR

1. Walker, John. "Cooperative Testing of Municipal Sludges by the Toxicity Characteristic Leaching Procedure and Compositional Analysis." In: *Proceedings of the National Conference on Municipal Sludge Treatment Plant Sludge Management*. May, 1988.

2. U.S. EPA. *Technical Support Document for Incineration of Sewage Sludge*. Prepared by Abt Associates for EPA Office of Water, Draft, September 1988.

3. R.C. Adams, G. Bockol, J.A. Maddox, and E.V. Robb, Radian Corporation, *Particulate Removal Evaluation of an Electrostatic Precipitator Dust Removal System Installed on a Multiple Hearth Incinerator Burning Sewage Sludge*, September 1985. R.C. Adams, L.E. Keller, and E.V. Robb, Radian Corporation, *Particulate Removal Capability of a Baghouse Filter on Exhaust of a Multiple Hearth Furnace Burning Sewage Sludge*, September 1986.

4. Al Baturay of Carlson Associates Technical Services, Inc.

5. National Incinerator Testing and Evaluation Program of Canada. *Air Pollution Control Technology*. Publication No. EPS 3/UP/2.

6. Same as Note 2.

7. Al Baturay of Carlson Associates Technical Services, Inc. developed these costs by computing heat and material balances for the different sizes and types of equipment. From these calculations, sizes of necessary control equipment were determined. Equipment vendors were contacted for estimating capital and operating costs. Installation costs were developed based on a fraction of the capital cost and the difficulty of the installation. Operating costs include power, fuel, maintenance, and labor.

8. Al Baturay of Carlson Associates Technical Services, Inc., estimated the number of units in each size and type category using ERG's list of incinerator installations, equipment supplier lists, and records of past clients operating sewage sludge incinerators.

9. U.S. EPA. *Operation and Maintenance Costs for Municipal Wastewater Facilities*, Technical Report, September 1981.

10. U.S. EPA. *Cross Media Impacts of Utilization and Disposal of Municipal Sludges*. Prepared by Temple, Barker & Sloane, Draft, May 1986.

11. U.S. EPA. *Site One Draft Emission Test Report: Sewage Sludge Test Program*, July 17, 1987; *Site Two Draft Emission Test Report: Sewage Sludge Test Program, Vol. 1, Emission Test Results*, Oct. 19, 1987; *Site Three Draft Emission Test Report: Sewage Sludge Test Program*, Oct. 1, 1987; *Site Four Draft Final Emission Test Report: Sewage Sludge Test Results*, May 9, 1988.

12. Al Baturay of Carlson Associates Technical Services, Inc., and unpublished data on monitoring and recording equipment costs, Office of Air Quality Planning and Standards, U.S. EPA.

13. Carpenter, Carey, and Al Rubin, 1988. "Ground-water Classification at Active Sludge Monofill Sites." ICF memorandum dated April 15, 1988.

14. U.S. EPA. Process Design Manual: Land Application of Sewage Sludge. Municipal Environmental Research Laboratory, Cincinnati, OH, 1983. EPA-625/1-83-016.

15. Same as Note 14.

2123S

SECTION FIVE

THE EFFECT OF PRETREATMENT ON SLUDGE QUALITY

The implementation of pretreatment can have a dramatic effect on pollutant levels in POTW sludges. For some POTWs, one or two dischargers may be the primary source of troublesome pollutants. Strict pretreatment controls on these few sources can improve the overall sludge quality for the POTW. Other POTWs may have numerous dischargers of varying sizes that are responsible for high contaminant levels in the sludge. In this case, widespread implementation of pretreatment may be necessary to improve sludge quality.

The National Pretreatment Program requires certain POTWs to control the level of contaminants in their influent through the implementation of four types of federally enforceable pretreatment standards:

- National categorical pretreatment standards. These technology-based standards require pretreatment controls according to the industry category of the discharger.
- Prohibited discharge standards (general). These standards apply to all dischargers, and prohibit the discharge of pollutants that are a fire or explosion hazard, corrosive, solid or viscous, or in large enough volumes or at high enough temperatures so as to cause interference with POTW operations.
- Prohibited discharge standards (specific). These standards prohibit the discharge of any pollutants into the sewage system if they pass through the POTW untreated or interfere with POTW operations.
- Local discharge limits. These limits are developed and enforced by local (POTW) pretreatment programs to implement the general and specific prohibited discharge standards and, if necessary, prevent localized pass-through and interference problems not controlled by the categorical pretreatment standards.

Thus, POTWs can control pollutants in industrial influents through (a) industry-specific standards (categorical standards); or (b) site-specific standards that apply to all or selected industrial dischargers in their service territory (prohibited discharge standards and local limits programs).

EPA conducted several case studies to determine the effect of specific control technologies on a POTW's ability to comply with the numerical pollutant limits of the proposed sludge disposal regulations. The control technologies used in these case studies, which vary by industry, are discussed below in Section 5.1. The current categorical standards for an industry are based on the best available technology (the technology that achieves the highest removal) that is economically achievable. Additional pollutant removals may be possible through more stringent control technologies, but may be more costly to the industrial discharger.

The case studies analyzed the effects of requiring the best available technologies of all categorical dischargers. The current status of the POTW's pretreatment program was used as the baseline in each case study. Thus, if certain categorical dischargers were not in compliance with the current standards, it was assumed that they would realize the full pollutant reductions attainable by installing the best available technology. Those industrial dischargers already in compliance would realize the incremental pollutant reductions attainable by upgrading to the best available technology.

The National Pretreatment Program (through the use of pretreatment standards) will require POTWs to control their industrial discharges to meet the new pollutant limits set for their sludges - unless the POTW can achieve compliance through other means or switch to a less restrictive disposal option. Therefore, additional pretreatment controls will be a way to achieve compliance with the new sludge disposal regulations.

In this RIA, the pretreatment case studies are used to determine whether compliance with the proposed regulations could be achieved through tighter pretreatment controls on categorical dischargers raher than through changing sludge disposal practices. The case study analysis has certain limitations (see Section 5.4) that restrict the applicability of its conclusions. The results have not, therefore, been incorporated into the compliance strategies or the costs of the regulatory options discussed in this RIA. However, pretreatment is an important mechanism available to POTWs to alleviate their sludge disposal problems. Further study in this area is warranted and may be included in subsequent regulatory analyses.

5.1 Case Studies

Eight POTWs and their industrial contributors subject to categorical standards were studied to determine the potential reduction in total loadings of various pollutants through stricter pretreatment. For purposes of this study, stricter pretreatment refers to the requirement for pollutant reductions from industrial dischargers beyond those required by the categorical pretreatment standards. The potential improvement was based on a scenario that assumed categorical industrial contributors in the service area of each case study POTW installed and operated the most stringent pretreatment technology (the best available technology).

The treatment plants chosen for this study represent a cross-section of sludge disposal options, POTW size, and industrial contribution in their influent. Table 5-1 summarizes the relevant characteristics of each case study POTW. Data regarding sludge quality and industrial influent from individual dischargers were collected. Current pretreatment practices were also investigated.

The pretreatment technologies currently specified in the existing categorical standards are referred to as "pretreatment standards for existing sources" (PSES). The most stringent technology for each categorical industry is referred to as SPS. SPS technology options for the following categorical industries were analyzed: inorganic and organic chemicals; leather tanning; electrical and electronic components; metal finishing and electroplating; plastics molding and forming; textiles; printing and publishing; pulp and paper; metal molding and casting; nonferrous metals manufacturing; iron and steel; auto and other laundries; battery manufacturing; and paint formulating. These industries were chosen because they occurred frequently among the case study POTWs and because they use toxic metals and organic compounds of concern to this analysis.

TABLE 5-1

PRETREATMENT CASE STUDY PROFILES

POTW NAME	LOCATION	SIZE (AVERAGE MGD)	SLUDGE DISPOSAL METHOD	PERCENT INDUSTRIAL INFLUENT	CONTRIBUTING INDUSTRIES ANALYZED
Westerly Plant - Northeast Ohio, Regional Sewer District	Cleveland, OH	46.9	Incineration	9%	2 inorganic and organic chemicals; 19 electroplating/metal finishing; 1 iron and steel; 2 metal molding and casting, aluminum; 5 printing and publishing; 2 paint and ink; 1 textiles; 2 plastic molding and forming; 6 industrial laundries; 2 car wash and other.
Muscatine WPCP	Muscatine, IA	7.6	Land application; non-food	52%	1 electroplating/metal finishing; 1 leather tanning.
Goshen WPCP	Goshen, IN	3.24	Land application	12%	3 electroplating/metal finishing; 2 paint and ink.
Newburyport WWTP	Newburyport, MA	2.0	Landfill	4%	4 electroplating/metal finishing.
River Road	Wichita Falls, TX	11.0	Land application	50%	4 electroplating/metal finishing; 1 battery manufacturing.
Passaic Valley	Newark, NJ	300.0	Ocean	47%	4 inorganic chemicals; 78 electroplating/metal finishing; 1 iron and steel; 3 leather tanning; 4 pulp and paper; 3 metal molding and casting, aluminum and copper; 4 plastic molding and forming; 1 battery manufacturing; 3 nonferrous metals manufacturing; 33 textiles.

TABLE 5-1 (CONT.)

POTW NAME	LOCATION	SIZE (AVERAGE MGD)	SLUDGE DISPOSAL METHOD	PERCENT INDUSTRIAL INFLUENT	CONTRIBUTING INDUSTRIES ANALYZED
Trinity River Authority	Grand Prarie, TX	84	On-site sludge landfill	10%	16 electroplating/metal finishing; 2 pulp and paper; 2 printing and publishing; 1 inorganic chemicals; 1 battery manufacturing; 3 plastics; 12 electrical and electronic components.
Green Bay Metro Sewerage District	Green Bay, WI	35	Incineration	Not given	8 electroplating/metal finishing; 3 pulp and paper; 1 iron and steel; 4 industrial laundries - car wash and other; 1 non-ferrous metals manufacturing.

1369S

The basis for selecting the SPS technologies, the costs of each technology, and the incremental pollutant removals were derived from EPA development documents and administrative records for the categorical pretreatment standards. Representative model plants from these sources were chosen to provide the basis for the costs and expected improvements as a result of SPS technologies for each industry category. A description of each industry model (and the PSES and SPS options assumed) is provided in Appendix A.

For each case study POTW, the total loadings from known industrial contributors for several metals and the chemical BEHP were calculated. The listings of industrial contributors were generally obtained from the Industrial Waste Surveys conducted by each POTW. The annual loadings of pollutants to the POTW from each contributor were calculated using influent sampling results and the total yearly flow from each discharger. Where influent sampling data were not available, pollutant levels in raw discharges of the industry's model plants (from EPA development documents) were used.

The reduction in individual pollutants that can be achieved from industry-specific SPS technology was applied to the total loadings of each industrial discharger to determine the mass of pollutants that could potentially be removed. Table 5-2 lists the estimated percent reduction in pollutants for the industrial model plants switching from PSES to SPS, or no pretreatment to SPS. The percent reduction in pollutants assumed for each industrial contributor in the case studies depended on whether or not that contributor was already in compliance with the categorical pretreatment standards. This information was known for some of the case study POTWs; where unknown, it was conservatively assumed that industrial contributors were already in compliance with PSES. For those contributors already in compliance with PSES, the reduction in pollutant loadings was based on switching from PSES to SPS. The improvement for plants with no pretreatment systems was based on the total percent reduction attainable from installing SPS systems.

Most industrial users subject to the categorical pretreatment standards should already have installed PSES to be in compliance with the regulations.

TABLE 5-2

ESTIMATED PERCENT REMOVAL OF SPS OPTIONS

INDUSTRY AND PRETREATMENT SCENARIO	INCREMENTAL PERCENT OF POLLUTANT REMOVED^a							
	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	BEHP
Inorganic Chemicals								
No Pretreatment to SPS	NA	99	97	99	NA	98	86	NA
PSES to SPS	NA	96	30	86	NA	42	68	NA
Leather Tanning								
No Pretreatment to SPS	NA	100	0	88	NA	0	0	NA
PSES to SPS	NA	98	0	88	NA	0	0	NA
Metal Finishing and Electroplating								
No Pretreatment to SPS	97	100	100	96	NA	100	100	NA
PSES to SPS	97	99	97	96	NA	98	97	NA
Metal Molding and Casting, Aluminum Subcategory								
No Pretreatment to SPS	NA	NA	95	97	NA	95	100	100
PSES to SPS	NA	NA	0	33	NA	0	32	0
Metal Molding and Casting, Copper Subcategory								
No Pretreatment to SPS	98	NA	100	99	NA	98	100	98
PSES to SPS	0	NA	0	0	NA	0	0	0
Metal Molding and Casting, Ferrous Subcategory								
No Pretreatment to SPS	96	96	98	100	NA	96	100	96
PSES to SPS	0	0	0	0	NA	0	0	0
Non-ferrous Metals Manufacturing								
No Pretreatment to SPS	96	100	100	99	NA	100	100	NA
PSES to SPS	0	0	NA	0	NA	0	0	NA

TABLE 5-2 (cont.)

INDUSTRY AND PRETREATMENT SCENARIO	INCREMENTAL PERCENT OF POLLUTANT REMOVED[a]							
	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	BEHP
Auto and Other Laundries, Car Wash Subcategory								
No Pretreatment to SPS	0	29	28	96	NA	0	85	0
PSES to SPS	0	29	28	96	NA	0	85	0
Auto and Other Laundries, Industrial Laundry Subcategory[b]								
No Pretreatment to SPS	17	87	77	98	NA	0	93	0
PSES to SPS	17	87	77	98	NA	0	93	0
Battery Manufacturing								
No Pretreatment to SPS	68	96	91	100	100	88	98	NA
PSES to SPS	0	17	57	NA	NA	71	33	NA
Electrical and Electronic Components								
No Pretreatment to SPS	96	89	24	99	NA	NA	99	NA
PSES to SPS	30	17	24	40	NA	NA	0	NA
Plastics Molding and Forming								
No Pretreatment to SPS	NA	NA	NA	NA	NA	NA	62	90
PSES to SPS	NA	NA	NA	NA	NA	NA	62	90
Textiles[b]								
No Pretreatment to SPS	NA	40	40	NA	NA	NA	39	95
PSES to SPS	NA	40	40	NA	NA	NA	39	95
Metal Molding and Casting, Zinc Subcategory								
No Pretreatment to SPS	95	95	99	96	NA	95	100	95
PSES to SPS	0	0	0	0	NA	0	0	0

TABLE 5-2 (cont.)

INDUSTRY AND PRETREATMENT SCENARIO	INCREMENTAL PERCENT OF POLLUTANT REMOVED[a]							
	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	BEHP
Printing and Publishing								
No Pretreatment to SPS	NA	100	87	100	NA	0	96	NA
PSES to SPS	NA	92	23	96	NA	0	96	NA
Iron and Steel								
No Pretreatment to SPS	NA	NA	NA	NA	NA	NA	0	NA
PSES to SPS	NA	NA	NA	NA	NA	NA	0	NA
Paint Formulating[b]								
No Pretreatment to SPS	100	100	100	100	100	100	100	100
PSES to SPS	100	100	100	100	100	100	100	100
Organic Chemicals								
No Pretreatment to SPS	NA	44	96	99	NA	7	87	98
PSES to SPS	NA	0	0	0	NA	0	0	0
Pulp and Paper								
No Pretreatment to SPS	NA	0	0	NA	NA	0	0	0
PSES to SPS	NA	0	0	NA	NA	0	0	0

[a] Two figures expressing percent removal are provided. The first refers to the incremental pollutant removal achieved when SPS is installed where there was previously no pretreatment. The second figure refers to the additional removal achieved by SPS over that achieved by PSES.

[b] There are currently no PSES requirements for these industries.

NA = Not applicable. Pollutants are not commonly associated with discharges from these industries.

Source: Industrial Technology Division, EPA, Washington, DC.

1438S

By the time the data were collected for these case studies; however, some had not done so. Since the data received from individual case study POTWs reflected the current status of all industrial contributors, the current status was used as the baseline. Therefore, the case study results reflect the improvement potential through stricter pretreatment and, in some cases, through bringing all categorical industries into compliance.

The total annual mass of pollutants estimated to be removed from each discharger as a result of stricter pretreatment was aggregated for each POTW. This figure was compared to the POTW-wide total annual loadings of each pollutant. Thus, an overall percent reduction in each pollutant was calculated for each POTW.

The results of the case study analyses are presented in Table 5-3. These results are estimates of the percent reduction in total yearly pollutant loadings to the POTW if categorical industrial dischargers install SPS technologies. The estimated reductions for each pollutant vary widely across POTWs. Six out of the eight case study POTWs attained additional reductions of over 90 percent in at least one pollutant. On an average basis for all plants, chromium and nickel levels show the greatest improvements.

Pollutant reductions as a result of stricter pretreatment will vary for each POTW, based on the types and the sizes of industrial contributors in the POTW system. The extent to which the categorical standards have already been implemented will also be a strong factor. Although the most significant improvements are attained with PSES, substantial additional reductions can be achieved with SPS. When upgrading from PSES to SPS, over 90 percent reductions can be achieved in at least one pollutant for 9 of the 17 industries examined.

5.2 The Cost to Industry of Implementing Stricter Pretreatment Programs

The incremental capital and annual operating and maintenance costs for the pretreatment options studied are presented in Table 5-4. Costs for upgrading

TABLE 5-3

ESTIMATED PERCENT REDUCTION IN POLLUTANTS FOR CASE STUDY POTWs

POTW	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	BEHP
River Road	1.0	4.4	1.4	0.2	-	98.5	0.5	-
Newburyport	1.75	0.92	1.39	1.74	-	6.9	0.85	-
Muscatine	0.9	98	1.1	20.9	-	13.1	0.5	-
Goshen	97	99	4.0	41.1	-	11.1	47.7	-
Passaic Valley	10.1	100	55	15.7	-	100	10.2	-
Westerly	49.9	95.4	87.2	96	-	94.3	98.3	-
Trinity	17.4	97.5	9.4	9.2	-	65.9	17.3	-
Green Bay	0.5	11.4	2.4	6.1	0	6.9	41.0	-
Average	22.3	63.3	20.2	23.9	ID	49.6	27.0	-

ID = Insufficient data.

Source: ERG analyses.

Note: Percent reductions apply to the current influent pollutant loadings.

1439S

TABLE 5-4

INCREMENTAL CAPITAL AND O&M COSTS FOR SPS PRETREATMENT TECHNOLOGIES

($ 1987)

INDUSTRY	INCREMENTAL COST PER DISCHARGER ($000)	
	PSES - SPS	
	CAPITAL	ANNUAL O&M
Inorganic Chemicals	153	84
Metal Finishing/Electroplating	111	67
Leather Tanning	1,765	395
Metal Molding & Casting, Aluminum	4	5
Metal Molding & Casting, Copper	0	0
Metal Molding & Casting, Ferrous	0	0
Metal Molding & Casting, Zinc	0	0
Printing & Publishing	2	2
Pulp & Paper	0	0
Iron & Steel	799	790
Paint Formulating[a]	143	69
Organic Chemicals	NA	NA
Auto & Other Laundries, Car Wash Subcategory	242	115
Auto and Other Laundries, Industrial* Laundries Subcategory	242	115

TABLE 5-4 (cont.)

	INCREMENTAL COST PER DISCHARGER ($000)	
	PSES - SPS	
INDUSTRY	CAPITAL	ANNUAL O&M
Battery Manufacturing	22	9
Electrical & Electronic Components	17	7
Plastics Molding & Forming	97	43
Textiles*	2,672	881
Non-Ferrous Metals	0	0

[a] Currently no PSES requirements.

NA = Not Available.

Source: EPA, ITD, March 1987.

from PSES to SPS are also presented. On an individual industrial plant basis, upgrade costs from PSES to SPS are highest for the textile industry: $2.5 and $0.84 million, for capital and O&M costs, respectively. (Note that in this case upgrading is the same as going from no pretreatment to SPS since there are currently no specific PSES limits for textiles.)

Only the incremental costs associated with upgrading from PSES to SPS were included in these totals. Although certain dischargers were not in compliance with PSES, they would have eventually made the expenditures required to comply. For those dischargers, the costs of PSES were subtracted from total costs of SPS.

The costs of pretreatment technologies were based on process flows and other relevant characteristics of the model plants for each industry category as described in Appendix A. These models were chosen to represent the most common plants in each industry category. The incremental costs estimated for the model plants were adjusted for each industrial discharger using a common engineering scaling factor based on the flow volume.

Table 5-5 presents the total cost of stricter pretreatment on a per POTW basis. These costs represent the total capital and O&M costs to all affected industrial dischargers in the POTW's service area. These costs will not be incurred by the POTW, but rather by the dischargers ordered by the POTW to upgrade pretreatment systems.

The larger plants with many categorical industrial contributors have the highest costs, as shown in Table 5-5. Passaic Valley receives influent from 33 textile mills, which account for a significant portion of the costs due to the high capital and operating costs of SPS for this industry.

5.3 The Effect of Pretreatment on the Ability of the Case Study POTWs to Comply With the Proposed Regulations

The improvement in sludge quality resulting from implementing pretreatment may be an important factor in a POTW's ability to comply with the proposed

TABLE 5-5

TOTAL INCREMENTAL COSTS OF STRICTER PRETREATMENT FOR THE CATEGORICAL INDUSTRIES OF EACH POTW

($ 1987)

	TOTAL INCREMENTAL COSTS ($000)			
	CAPITAL	ANNUALIZED CAPITAL[a]	O&M	TOTAL ANNUAL
Goshen	900	118	504	622
River Road	505	66	281	347
Muscatine	2,175	286	569	855
Westerly	3,423	450	1,896	2,346
Trinity River	4,654	612	2,492	3,104
Passaic Valley	35,352	4,648	13,079	17,727
Newburyport	188	25	114	139
Green Bay	1,364	179	765	944

[a] Annualized assuming 10 percent interest rate and 15-year equipment life.

sludge disposal regulations. This aspect of pretreatment was analyzed for the case study POTWs. The percent reductions in pollutant loadings to the POTW estimated in Section 5.1 were used as a proxy for the percent reduction possible in sludge contaminant levels.

Table 5-6 shows the results of this analysis for each case study POTW. The projected sludge quality, after SPS had been implemented, was determined based on the existing sludge quality and the estimated improvement for individual contaminants for each POTW (see Table 5-3). Table 5-6 also shows the maximum sludge concentrations allowed for compliance with the proposed regulations.

The maximum concentrations shown for each POTW reflect Option 3 criteria relevant to the particular disposal method used. The two case study plants using incineration are also numbers 7 and 8 of the 10 model incinerators used in Section 4.1. Therefore, the maximum pollutant concentrations calculated for those specific models were used in this analysis. For those case study POTWs using land application, maximum pollutant concentrations corresponding to Option 3 nonagricultural land application criteria were used. This set of criteria were chosen since agricultural land application rules specify application rates, not maximum pollutant concentrations, in sewage sludge.

The results associated with Option 3 are shown in Table 5-6. Although significant improvements in sludge quality are obtained, only the Goshen plant can effect compliance for all pollutants analyzed if additional pretreatment by categorical industries to the level shown is achieved. For plants using incineration and monofills, the criteria are stringent enough that even a substantial improvement in certain contaminants is insufficient to attain compliance.

Not all the regulated pollutants (pollutants covered by the proposed sludge disposal regulations) were covered by the pretreatment case study analysis and not all case study POTWs had sludge quality data for all pollutants that were studied. Therefore, Table 5-6 does not include data for all the regulated pollutants. The pass/fail decision was based only on those contaminants shown.

TABLE 5-6

PASS/FAIL ANALYSIS FOR CASE STUDY POTWS

POLLUTANT	EXISTING SLUDGE QUALITY (MG/KG)	PROJECTED QUALITY AFTER PRETREAT. (MG/KG)	MAXIMUM SLUDGE CONC. (MG/KG)	PASS/FAIL RESULTS	
				EXISTING	PROJECTED
TRINITY RIVER--ONSITE SLUDGE LANDFILL					
CADMIUM	31	25.73	9.44	FAIL	FAIL
CHROMIUM	228	2.052	NA		
COPPER	550	515.9	NA		
LEAD	141	133.527	500	PASS	PASS
NICKEL	61	21.045	NA		
ZINC	570	553.47	NA		
CLEVELAND WESTERLY--INCINERATION					
CADMIUM	108	78.192	0.55	FAIL	FAIL
CHROMIUM	802	166.816	9.51	FAIL	FAIL
COPPER	NA	NA	NA		
LEAD	NA	NA	52.15		
NICKEL	389	21.784	3.6	FAIL	FAIL
ZINC	NA	NA	NA		
PASSAIC VALLEY--OCEAN DISPOSAL					
CADMIUM*	2.7	2.5677	34072.25	PASS	PASS
CHROMIUM	110	0.88	NA		
COPPER	110	88	NA		
LEAD	170	166.94	NA		
NICKEL	12	7.584	NA		
ZINC	150	139.5	NA		
CITY OF GOSHEN--LAND APPLICATION					
CADMIUM	529.5	15.885	384	FAIL	PASS
CHROMIUM	3242	32.42	3063	FAIL	PASS
COPPER	1409	1352.64	3300.3	PASS	PASS
LEAD	178.9	105.551	1622.8	PASS	PASS
NICKEL	955	848.995	988	PASS	PASS
ZINC	13704	7167.192	8622.4	FAIL	PASS

TABLE 5-6 (CONT'D)

POLLUTANT	EXISTING SLUDGE QUALITY (MG/KG)	PROJECTED QUALITY AFTER PRETREAT. (MG/KG)	MAXIMUM SLUDGE CONC. (MG/KG)	PASS/FAIL RESULTS	
				EXISTING	PROJECTED
RIVER ROAD--LAND APPLICATION					
CADMIUM	0.006	0.00594	384	PASS	PASS
CHROMIUM	NA	NA	3063		
COPPER	0.024	0.023688	3300.3	PASS	PASS
LEAD	0.056	0.055888	1622.8	PASS	PASS
NICKEL	NA	NA	988	PASS	PASS
ZINC	0.504	0.50148	8622.4	PASS	PASS
GREEN BAY--INCINERATION					
CADMIUM	18.065	17.97467	2.47	FAIL	FAIL
CHROMIUM	572.6666	507.3826	42.77	FAIL	FAIL
COPPER	688.5	671.976	NA		
LEAD	284.8333	267.4585	234.6	FAIL	FAIL
NICKEL	264.5	246.2495	16.2	FAIL	FAIL
ZINC	1451.833	856.5816	NA		

Source: ERG estimates.

*Maximum sludge concentration was calculated for standard discharge rate of 15,500 gallons per minute. If the actual sludge concentration had exceeded this value, the sludge would not have failed, but the discharge rate would have had to have been reduced.

5.4 Limitations to the Analysis

A major limitation to the methodology is that only potential improvements in sludge quality among the categorical dischargers were analyzed. In addition, categorical industries include only a portion of the industrial dischargers that fall under the mandates of the pretreatment standards. Although SPS provides additional pollutant reductions over PSES, requiring pretreatment for noncategorical industrial dischargers could realize greater reductions in pollutants. This scenario would be more cost-effective since, in general, reducing the pollutant discharge levels (the initial 90 percent) using a PSES technology (such as lime and settle at a noncategorical industry) is more efficient than adding an SPS technology (such as a polishing filter), to increase pollutant removals from 90 to 99 percent at a categorical industry. However, the data and the resources needed to perform an analysis of the noncategorical dischargers were not available for these case studies.

Another limitation is the use of one model plant to represent the cost for dischargers in each industry category. Although a scaling factor was used to adjust these costs to the individual dischargers, actual costs may vary significantly. This methodology does, however, provide a rough approximation of the associated incremental costs potentially faced by industry. Since the main goal of the analysis was to evaluate the potential role of pretreatment in complying with the proposed sludge disposal regulations, this method is justifiable.

SECTION SIX

POPULATION RISK ASSESSMENT AND BENEFITS OF TECHNICAL REGULATIONS FOR SEWAGE SLUDGE USE AND DISPOSAL[1]

This section of the RIA provides a brief description of the methods and data sources used to calculate benefits and presents both quantitative and qualitative results. A more detailed description of the methodological approach and findings, including sensitivity analyses, is provided in the Abt Associates report to EPA/OWRS, Aggregate Risk Assessment of Municipal Sewage Sludge.

This section of the RIA measures benefits as the reduction in human health risk resulting from controls on the use and disposal of sewage sludge. Benefits are presented as numbers of disease cases avoided annually. Section 6.1 outlines the general analytical framework for estimating risk-based benefits. Section 6.2 indicates how this framework is used to estimate risks from the use and disposal of municipal sewage sludge. The remaining section, Section 6.3, describes the risks and benefits for each of the five major sludge use and disposal practices being considered for regulation. These practices are incineration, landfilling in sludge-only monofills, land application, distribution and marketing, and surface impoundments. Risk and benefits of disposing of sludge in surface impoundments have not yet been quantified. The risks and benefits of sludge codisposed in municipal landfills is also not estimated since this practice will be covered by proposed and existing regulations under Subtitle D of the Resource Conservation and Recovery Act. The specific compliance strategies for each of the disposal practices covered by the proposed sewage sludge regulations are not examined here but are covered in Section Four of this report. Finally, Section 6.4 provides a qualitative discussion of environmental (i.e., nonhealth) benefits.

6.1 General Framework for Risk-Based Benefit Analysis

As discussed above, this section of the RIA estimates benefits by using risk assessment methods to calculate reductions in risks to human populations resulting from controls on sewage sludge disposal. The framework for conducting such a benefits analysis is illustrated in Figure 6-1. The process begins with a baseline estimate of risk by determining the current releases of sludge contaminants into the environment. These contaminant levels are then used to calculate baseline human health or ecological risk. Next, the risk estimates are recalculated to reflect the implementation of regulatory controls. The new risk estimates are then compared to the baseline risks, and benefits are derived as the change in risks from the baseline after the control technique is implemented. Benefits are positive when risks are reduced.

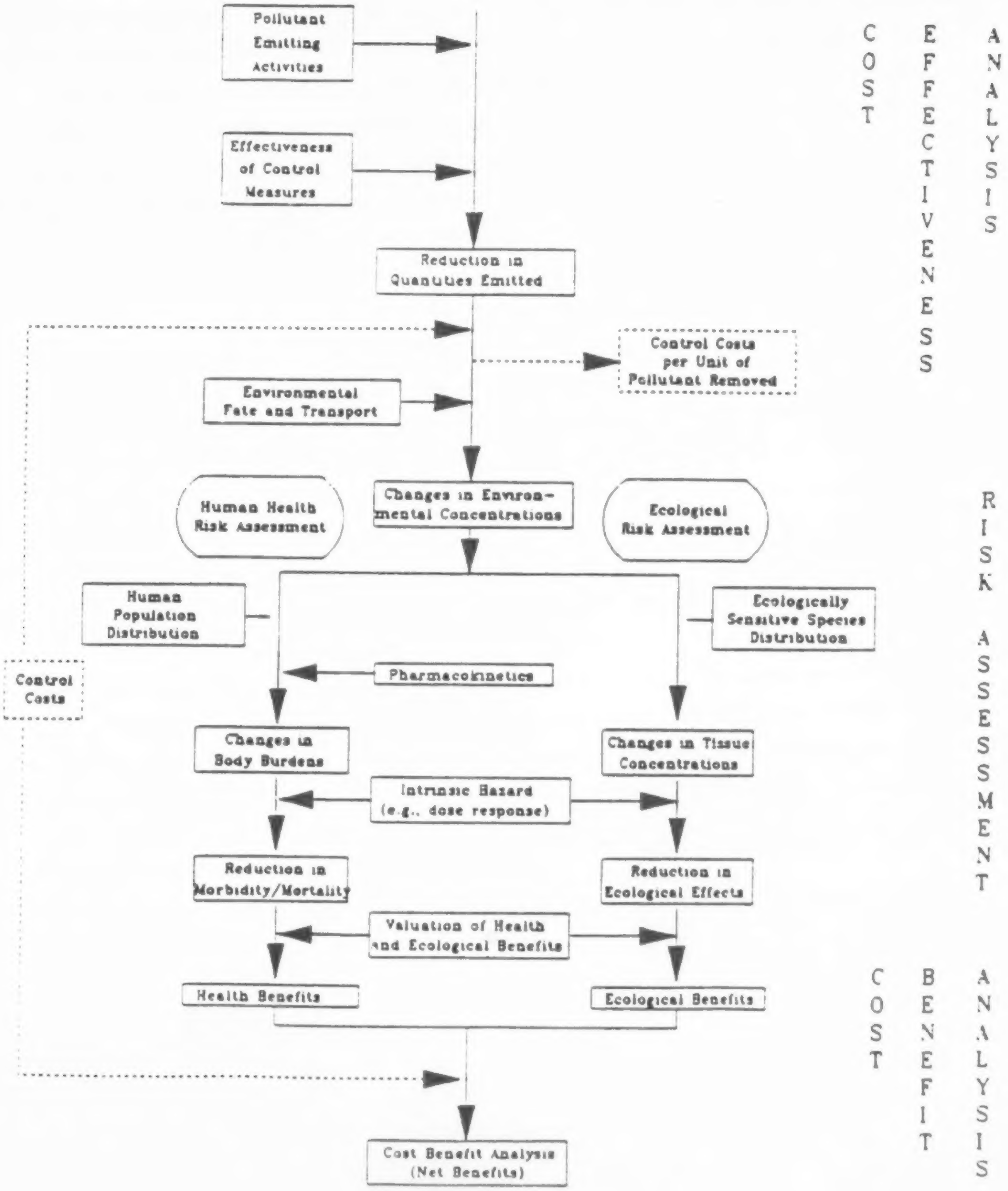
Figure 6-1 presents the three steps taken to calculate the risks of baseline practices and regulatory benefits: the cost effectiveness analysis, the risk assessment and the cost/benefit analysis. The first step in the process, the cost effectiveness analysis, is used in this study to provide the reduction in quantities of pollutants emitted to the environment, which is then used as input to the benefits analysis. (This step can be used to determine the cost effectiveness of a regulation, i.e., the costs per unit of pollutant removed. Cost effectiveness analysis is commonly performed on industrial effluent guidelines. In this case the analysis ends here and risks and benefits are not calculated.)

The risk assessment step is illustrated in the middle portion of Figure 6-1. The risk assessment identifies the health and/or ecological changes that occur when a pollutant is removed from the environment after controls are applied. Risk assessment begins with a hazard identification and a source assessment and continues with fate and transport estimates, exposure assessments, pharmacokinetics analysis and dose-response assessments. These components of the risk assessment, described later in this section, are used to develop the changes (typically reductions) in health, measured as morbidity (illness) and mortality, and ecological effects. These reductions in human health or ecological risks are the benefits of regulatory control.

The final step in the analysis is the cost/benefit analysis. Several components of this step, shown in the lower portion of Figure 6-1, are not

Figure 6-1

Framework for
Human Health and Ecological Benefits Evaluation


Pollutant Emitting Activities
Effectiveness of Control Measures
Reduction in Quantities Emitted
Control Costs per Unit of Pollutant Removed
Environmental Fate and Transport
Human Health Risk Assessment
Changes in Environmental Concentrations
Ecological Risk Assessment
Human Population Distribution
Ecologically Sensitive Species Distribution
Control Costs
Pharmacokinetics
Changes in Body Burdens
Changes in Tissue Concentrations
Intrinsic Hazard (e.g., dose response)
Reduction in Morbidity/Mortality
Reduction in Ecological Effects
Valuation of Health and Ecological Benefits
Health Benefits
Ecological Benefits
Cost Benefit Analysis (Net Benefits)
COST EFFECTIVENESS ANALYSIS
RISK ASSESSMENT
COST BENEFIT ANALYSIS

used in this analysis. For example, a monetary measure of benefits can be developed as part of a cost/benefit analysis. This valuation of benefits component is not part of the risk assessment but can be a useful addition to a benefits analysis. This RIA, however, does not attempt to establish the monetary value of reducing the human health risks identified in the analysis because of several problems inherent in the analysis of monetary benefits. Currently, EPA suggests a value of $400,000 to $7,000,000 for preventing a statistical death.[2] These guidelines do not differentiate among various forms of illness, some of which are more severe than others. Since many of the health effects identified in this study involve morbidity rather than mortality, the analysis is made more consistent by presenting benefits purely as reductions of human health risks (numbers of disease cases avoided).

Another step that is not used in this study, although it is presented in Figure 6-1, is the calculation of ecological benefits. This step was omitted because ecological benefits tend to be extremely site-specific, and data and methodologies to assess these benefits are not well developed at this time. Thus when the assessment of a sludge disposal method involves substituting human exposures for ecological exposures, only partial benefits (those associated with human health alone) will be calculated. This problem of undercounted benefits is particularly acute when the ecological risks are associated with long-term, difficult-to-detect damages.

The remainder of this section describes the approach to human health risk assessment used in this analysis of municipal sewage sludge disposal. The risk assessment follows the process outlined by the National Academy of Sciences,[3] which divides risk assessment into the following four components:

1. hazard identification
2. dose-response assessment
3. exposure assessment
4. risk characterization

Each component of the process is described in more detail below.

6.1.1 Hazard Identification

The hazard identification component of risk assessment consists of gathering and evaluating all relevant data that describe whether a chemical substance poses a specific hazard. It is a qualitative determination based on information such as the type of health effect produced, the conditions of exposure and the metabolic processes within the body that govern chemical behavior. Hazard identification determines whether it is scientifically appropriate to infer that effects observed under one set of conditions (e.g., in experimental animals) will occur in other settings (e.g., in humans). Generally, hazard identification focuses separately on carcinogenic and noncarcinogenic effects.

For carcinogenic substances, EPA has developed a formal, weight-of-evidence determination of health effects that combines much of the toxicological information that has been developed. The guidelines for carcinogenic risk assessment group all human and animal data reviewed into the following categories based on degree of evidence of carcinogencity:[4]

- sufficient evidence
- limited evidence
- inadequate evidence
- no data available
- no evidence of carcinogenicity

Human and animal evidence of carcinogenicity is then combined as illustrated in Table 6-1 into a weight-of-evidence classification scheme. The scheme includes the following groups:

- Group A - known human carcinogen
- Group B - probable human carcinogen; known animal carcinogen
- Group C - possible human carcinogen
- Group D - not classifiable as to human carcinogenicity
- Group E - evidence of noncarcinogenicity in humans

TABLE 6-1

CATEGORIZATION OF EVIDENCE OF CARCINOGENICITY BASED ON ANIMAL AND HUMAN DATA

	ANIMAL EVIDENCE				
HUMAN EVIDENCE	SUFFICIENT	LIMITED	INADEQUATE	NO DATA	EVIDENCE OF NO EFFECT
Sufficient	A	A	A	A	A
Limited	B1	B1	B1	B1	B1
Inadequate	B2	C	D	D	D
No Data	B2	C	D	D	E
Evidence of No Effect	B2	C	D	D	E

Source: U.S. EPA, 1986. Guidelines for Carcinogen Risk Assessment. 51FR33992.

Noncarcinogens are typically considered to have threshold effects. For carcinogens, however, EPA generally considers the risk to be linearly related to dose. This means that no dose is considered "safe;" only a zero dose is associated with zero risk. The methodologies for dose-response assessments for carcinogens and noncarcinogens are discussed separately below.

Carcinogens

Most dose-response assessments have been performed as part of carcinogen risk assessments. EPA guidelines provide detailed instructions on how to perform dose-response assessments.[5] EPA also provides guidance on such issues as choice of extrapolation model; how to consider benign tumors; and the adjustment of dosage from animals to humans. The standard EPA methodology for calculating dose-response for carcinogens uses a linear "multi-stage" dose-response curve. The output from the analysis of this curve is Q_1^*, the potency value, which is expressed in terms of risk per dose and is measured in units of $(mg/kg/day^{-1})$. The dose-response curve is adjusted to take into account most of the uncertainty associated with the dose-response assessment at low doses (this is the "multi-stage" aspect of the curve). This procedure produces a conservative estimate of risk - the actual risk is very likely to be lower than the calculated risk. The actual risk may, therefore, be as low as zero, but the estimated risk will always be higher than zero at any nonzero dose. This is the rationale behind the concept of the nonthreshold effect, where no level of exposure to carcinogens is considered safe.

The only other health effects for which EPA has officially recommended the use of nonthreshold dose-response assessment are mutagenic effects. Dose-response assessments of human mutagens, however, can at present only be performed using data on mutations induced in intact mammals (rather than in cell cultures). Since most of the data needed to assess the sludge contaminants of concern originate from in-vitro or nonmammalian test systems, and because of the uncertainty surrounding the choice of the appropriate extrapolation model,[7] this study does not attempt to derive dose-response relationships for human mutagenic effects.

EPA typically treats substances classified in Categories A and B as carcinogens, whereas those which fall in Categories D and E are treated as noncarcinogens. Chemical substances classified as Category C receive varying treatment. As part of the risk assessment analysis, this study provides the appropriate weight-of-evidence evaluation for each sludge constituent that EPA has evaluated for carcinogenicity.

For other, noncarcinogenic health effects (e.g., mutagenic effects, systemic toxicity), EPA's hazard identification/weight-of-evidence determination is not yet formalized and is more qualitative than that for carcinogens. Judgments on the relevance of data to determinations of noncarcinogenic health effects for a particular pollutant are more subjective than those for carcinogenic health effects. The following factors are evaluated in determining noncarcinogenic effects:

- quality of data
- resolving power of the studies (the statistical significance of the studies as a function of the number of animals or subjects)
- relevance of route and timing of exposure
- appropriateness of dose selection
- replication of effects
- number of species examined
- availability of human epidemiologic study data

6.1.2 Dose-Response Assessment

In dose-response assessment, the relationship between the amount of exposure to a contaminant (dose) and the extent of toxic injury or disease (response) is quantitatively estimated. Two general approaches can be taken to dose-response assessment depending on whether the health effects are "threshold" effects or "nonthreshold" effects. "Threshold" effects are defined when it is believed that there is some dose below which no effects on human health will occur. Doses below this level are considered "safe."

Noncarcinogens

Threshold effects, which apply primarily to systemic toxicants or other noncarcinogenic health effects, do not use dose-response curves. Rather Acceptable Daily Intake (ADI) values are calculated for each contaminant of concern. This measure is used as the threshold level below which a significant risk of adverse effects is not expected. More recently, EPA has preferred to use a new term, the Risk Reference Dose or RfD, to avoid the connotation of acceptability.

Briefly, the RfD methodology takes an appropriate lifetime-adjusted No Observed Effect Level (NOEL), No Observed Adverse Effect Level (NOAEL), Lowest Observed Effect Level (LOEL) or Lowest Observed Adverse Effect Level (LOAEL) - derived from either laboratory animal and/or human epidemiology data - and divides it by the appropriate uncertainty (safety) factors. Ideally, for all noncarcinogenic effects, a set of thresholds will be developed for each route of exposure and for each health effect. If information is available for only one route of exposure, this value is extrapolated to estimate an appropriate threshold for the other relevant routes of exposure.

EPA currently has no accepted method to determine the significance of the adverse health effects that may occur when populations are exposed to pollutants at concentrations exceeding the RfD level. Much work is underway, both within and outside EPA, to develop more quantitative approaches to dose-response assessment for noncarcinogens.

6.1.3 Exposure Assessment

Human exposure is evaluated by describing the nature and size of the population exposed to a substance and the magnitude and duration of its exposure. The major areas that must be evaluated when estimating exposure are:[8]

- o Source assessment - a characterization of the sources of contamination.

- Environmental fate and transport analysis - a description of how a contaminant may be transported from the source to the potentially exposed population.

- Estimate of environmental concentration - an estimate derived using monitoring data and/or modeling of contaminant levels away from a source.

- Population analysis - a description of the size, location and habits of potentially exposed human and environmental receptors.

- Integrated exposure assessment - the calculation of exposure levels and an evaluation of uncertainty. An integrated exposure assessment estimates the number of persons exposed to the substance under investigation through all exposure routes and through all pathways from the sources to the exposed individuals.

For risk assessments involving chronic exposure, human exposure in mg/kg/day is calculated as a dose averaged over body weight (kg) and lifetime (days):

$$\text{Average Daily Lifetime Exposure} = \frac{\text{Total Dose}}{\text{Body Weight} \times \text{Lifetime}}$$

The total dose (mg) can be expanded as follows:

$$\text{Total Dose} = \text{Contaminant Concentration} \times \text{Contact Rate} \times \text{Exposure Duration} \times \text{Absorption Fraction}$$

The four parameters in the second equation are defined as follows:

- Contaminant concentration represents the concentration of the contaminant in the medium (air, food, drinking water) contacting the body. Typical units are mass/volume (e.g., ug/l or ug/m^3) or mass/mass (e.g., mg/kg).

- Contact rate is the rate at which the medium contacts the body (through inhalation, ingestion or dermal contact); typical units are mass/time (e.g., mg/day) or volume/time (e.g., m^3/day or l/day).

- Exposure duration is the length of time an individual is in contact with the contaminant (e.g., lifetime).

- Absorption fraction is the effective portion of total contaminant contacting and entering the body. Entering the body means that the contaminant crosses one of the three exchange membranes: alveolar membrane (lungs), gastrointestinal tract, or skin.

6.1.4 Risk Characterization

The final step in the risk assessment process is risk characterization. This step puts together the information developed in the three previous steps (hazard identification, dose-response analysis, and exposure assessment). For noncarcinogens, this step compares the dose estimates (from the exposure assessment step) to the RfD (from the dose-response evaluation step) to estimate the relationship of dose to the threshold level.

For carcinogens, risk can be estimated by multiplying the actual human dose by the risk per unit of dose (the potency value Q_1^*) projected from the dose-response modeling. Total risk is then expressed as the risk to the maximum exposed individual (MEI) and as the risk to the aggregate population. Additionally, for carcinogens, the weight-of-evidence determination should be presented, based on the rankings shown in Table 6-1.

This final assessment also displays the distribution of exposure and risk across various populations, the estimated uncertainty of each component part and the key assumptions underlying the estimates. In this way, the qualitative and quantitative risk estimates are presented, and the information on which these derivations are based can be summarized. Section 6.3 provides all this information for each of the sludge disposal methods covered by the proposed regulations.

6.2 Application of Risk-Based Methodology to Sewage Sludge Use and Disposal

The first step in identifying the benefits from the sludge disposal regulations involves estimating the baseline human health risks of sludge disposal. Then, the appropriate control options can be examined and, subsequently, the change in risks from the baseline, i.e., the benefits of the regulation, can be quantified.

The key inputs for estimating baseline risks include source (POTW) information, sludge contaminants, and ultimate disposal site characteristics.

Baseline risks from the major sludge disposal practices are characterized based on three sludge pollutant concentration profiles (described in Section Three), the actual quantity of sludge generated by each POTW, and the fate and transport of the pollutants subsequent to disposal, depending on a number of different environments that vary with each disposal practice.

On the basis of these inputs, this study estimates the potential pathways of human exposure and models the fate and transport of the key sludge constituents for these primary pathways. The study then estimates the potential populations exposed. This information is coupled with dose-response data for each of the sludge contaminants of concern to characterize baseline human health risks. These risks are presented as risks to the maximum exposed individual as well as to the aggregate population. They are further disaggregated by contaminant, exposure pathway and disposal option.

Once baseline risks are derived, regulatory control options are added to the current disposal practices. The same risk assessment process is then used to derive a change in the baseline risk as a result of each control option by disposal method. This change from the baseline is the measure of benefit. The estimates of the change from baseline risks are presented by control option for each sludge disposal practice and are expressed as human health risk (to the maximum exposed individuals) or as the number of disease cases avoided (in the total population). These disease cases will frequently include cases of cancer avoided, but the results of the analysis will also specify any additional noncarcinogenic human health effects that are avoided when regulatory controls are applied.

Before the risks and benefits of controlling each of the major sludge disposal methods are discussed, the following sections discuss two key components common to the benefits analysis across all disposal practices. The first of these components, the health effects of the sludge constituents of concern, includes the hazard identification and dose-response assessment of the sludge constituents. The second key component includes the overall limitations and uncertainty inherent in this benefits analysis. Following the discussion of health effects and limitations, the results of the benefits analysis will be presented for each sludge disposal method in Section 6.3.

Other key components of this risk assessment and benefits analysis have been examined in Sections Three and Four of this report and will not be repeated here. These components include sludge contaminant characterization, disposal practice descriptions, the allocation of plants to sludge quality and disposal practice categories, and a description of control options and compliance strategies.

6.2.1 Health Effects Information

This section identifies the potential adverse health effects that may be associated with chronic exposure to the sludge contaminants of concern. Both qualitative (hazard identification) and quantitative (dose-response assessments) data, where available and applicable, have been used.

Three principal sources of information were used to obtain the health effects of the sludge contaminants of concern. EPA's Integrated Risk Information System (IRIS) was the primary source used. As a secondary source for those chemicals not yet included in the IRIS system, CAG and EPA's Environmental Criteria and Assessment Office (ECAO) were contacted directly to obtain the needed values. If data could not be obtained from any of these sources, they were then obtained from the EPA/OWRS technical support document for the relevant chemical/sludge disposal practice.

Table 6-2 presents the sludge contaminants that are known or suspected carcinogens with their qualitative (hazard identification) evaluation of weight-of-evidence and the appropriate Q_1^* (dose-response) value (see Section 6.1). Table 6-2 also presents the RfD values for each relevant sludge contaminant. These RfDs are used as threshold levels for critical noncarcinogenic effects. A significant risk of adverse effects is not expected at intake levels below the RfD. Note that for noncarcinogenic effects, EPA has not established a formal weight-of-evidence classification system. Thus the hazard identification process for noncarcinogens is more qualitative than that for carcinogens.

TABLE 6-2

SUMMARY OF HEALTH EFFECTS DATA FOR SEWAGE SLUDGE CONTAMINANTS OF CONCERN

	CARCINOGENS		NONCARCINOGENS
CONTAMINANT	WEIGHT OF EVIDENCE	q_1^* VALUE $(mg/kg/day)^{-1}$	RfD Value (mg/kg/day)
Acetonitrile	--	--	6.0×10^{-3}
Acrylonitrile	B1	2.4×10^{-1}	--
Aldrin	B2	1.6×10^{1}	3.0×10^{-5}
Arsenic	A	1.5×10^{1}	1.4×10^{-3}
BEHP	B2	1.41×10^{-2}	2.0×10^{-2}
Benzene	A	2.9×10^{-2}	--
Benzidine	A	2.34×10^{2}	--
Benzo(a)pyrene	B2	1.15×10^{1}	--
Beryllium	B2	7.0×10^{0}	5.0×10^{-3}
Cadmium	B1	6.1×10^{0}	2.0×10^{-3}
Carbon tetrachloride	B2	1.3×10^{-1}	7.0×10^{-4}
Chlordane	B2	1.3×10^{0}	5.0×10^{-5}
Chloroform	B2	8.1×10^{-2}	--
Chromium	A	4.1×10^{1}	5.0×10^{-3}
Copper	--	--	0.0
DDT	B2	3.4×10^{-1}	5.0×10^{-4}
1,2-Dichloroethane	B2	9.1×10^{-2}	--
2,4-Dichlorophenol	--	--	3.0×10^{-3}
Dieldrin	B2	2.0×10^{1}	--
Dimethylnitrosamine	B2	2.59×10^{1}	--
2,4-Dinitrophenol	--	--	2.0×10^{-2}
Heptachlor	B2	4.5×10^{0}	5.0×10^{-4}
Hexachlorobenzene	B2	1.67×10^{0}	--
Hexachlorobutadiene	C	7.75×10^{-2}	2.0×10^{-3}

TABLE 6-2 (continued)

	CARCINOGENS		NONCARCINOGENS
CONTAMINANT	WEIGHT OF EVIDENCE	q_1^* VALUE (mg/kg/day)-1	RfD Value (mg/kg/day)
Hexachlorodibenzo-p-dioxin mix	B2	6.2×10^3	--
Lead	a	—	--
Lindane	B2	1.33×10^0	--
Mercury	—	--	3.0×10^{-4}
Methylene chloride	B2	1.4×10^{-2}	--
Methyl ethyl ketone	—	--	5.0×10^{-2}
Molybdenum	--	--	0.0
Nickel	A	1.7×10^0	2.0×10^{-2}
PCBs	B2	7.7×10^0	—
Pentachlorophenol	—	—	3.0×10^{-2}
Phenol	—	—	4.0×10^{-2}
Selenium	—	—	4.5×10^{-3}
2,3,7,8-TCDD	B2	1.56×10^5	7.0×10^{-5} b
2,3,7,8-TCDF	--	—	2.0×10^{-5}
Tetrachloroethylene	B2	5.1×10^{-2}	--
Trichloroethylene	B2	1.3×10^{-2} (inh.) 1.1×10^{-2} (ing.)	--
1,2,4-Trichlorobenzene	--	—	2.0×10^{-2}
Toluene	--	—	3.0×10^{-1}
Toxaphene	B2	1.1×10^0	--
Vinyl chloride	A	2.3×10^0	--
Zinc	--	--	4.7×10^{-1}

[a] Lead threshold values: males, 7 ug/dl; females, 10 ug/dl; children, 12.5 mg/dl.

[b] In ug/kg/day.

Source: Abt Associates estimates.

For lead and cadmium, human health impacts were estimated in a slightly different way. For these two contaminants, sufficient data are available to support improved methods of predicting adverse health effects. Estimating the health effects of lead or cadmium involves predicting the concentration of the contaminant in body tissues of exposed individuals; this "body burden" is in turn affected by levels of environmental exposure. For lead, body burden is typically measured as the concentration of lead in an individual's blood (ug/dl); for cadmium, it is measured as the concentration of cadmium accumulated in an individual's kidney tissues (ug/g). For both metals, data are available (1) to describe background levels of tissue concentrations in the U.S. population, (2) to link levels of environmental exposure to expected increments in these tissue concentrations and (3) to link tissue concentrations to possible or expected health consequences.

For lead, data to connect health effects with background levels of lead in blood (blood-lead levels) are available for men, women, and children. Adverse fetal effects from lead have been detected statistically for women with blood-lead levels as low as 10 ug/dl; neurological and developmental effects have been detected in children with blood-lead levels between 10 and 15 ug/dl. For white men aged 40 to 59, increases in blood-lead levels have been found to be associated with increased blood pressure at blood-lead levels as low as 7 ug/dl. "Threshold" values of 7, 10, and 10 to 15 ug/dl were therefore selected to represent blood-lead levels above which men, women and children, respectively, might be adversely affected by lead exposure.

Similarly, data connecting elevated cadmium levels in the kidney with health effects are availale for both smokers and nonsmokers in the U.S. Adverse health effects from cadmium have been observed in adults with kidney cadmium levels exceeding 200 ug/g. A "threshold" value of 200 ug/g was therefore used in estimating potential health effects from cadmium.

From these data, the numbers of persons with cadmium and lead levels exceeding these threshold values as a result of background exposures from sources other than wastewater sludge were calculated. The incremental increase in the levels of cadmium and lead in the kidney or blood that could be attributed to sewage sludge use or disposal practices was then predicted.

The number of persons who exceeded the thresholds for cadmium and lead because of the use and disposal of sewage sludge was determined by subtracting the original number of persons whose levels exceeded the thresholds from the number of persons whose blood levels exceed the thresholds after the use and disposal of sewage sludge. The key parameters in this analysis are background mean tissue concentrations, the coefficients of variation, the incremental increase in body burdens of cadmium and lead caused by sewage sludge use and disposal practices, and the lead or cadmium levels that may cause a health effect.

The "threshold" approaches described above were used to predict the number of exposed individuals who might be vulnerable to adverse health effects as a result of exposure to cadmium or lead from sludge disposal. But not all of the individuals with lead or cadmium levels above the selected thresholds would be expected to experience actual health effects. In assessing health risks from lead, additional techniques were used to estimate the number of individuals likely to suffer the effects under consideration. For white males, for example, results from estimates of diastolic blood pressure versus blood-lead levels were used to relate shifts in average blood-lead levels to expected increases in the numbers of men with high blood pressure. As expected, the number of individuals expected to have high blood pressure as a result of lead exposure from sludge is smaller than the number of individuals exceeding 7 ug/dl blood lead as a result of sludge disposal. Similar methods were used to estimate other health effects from lead exposure, and results were used to supplement those from the "threshold" approaches.

6.2.2 Limitations/Uncertainty

Several limitations affect the predicted benefits results. Certain exposure pathways, contaminants or effects are excluded from the analysis, resulting in undercounted benefits. The reasons for these exclusions are discussed below.

Most importantly, ecological effects are not quantified in either the baseline or benefits analysis. Although some methodologies do exist for quantifying ecological effects, these methodologies typically use indices rather than actual damage measurements. Because many uncertainties and data gaps become apparent when these methodologies are used, it is difficult to express results meaningfully. Consequently, ecological effects are not examined quantitatively, but are reviewed qualitatively.

Another important limitation is the absence of an analysis to estimate risks from pathogenic organisms. EPA plans to regulate pathogens using a technology-based approach; however, the methodology for quantifying pathogenic risks is not yet complete. As a consequence, the baseline risks and benefits of controlling pathogenic organisms have not been estimated.

The third way in which benefits may have been understated is by omitting certain exposure pathways. For example, volatilization from land application of sludge, the removal and disposal of sludge incinerator ash, and the deposition of incinerator contaminants on crop land and surface waters were not analyzed. All these pathways could contribute to some additional baseline risk. Thus, to the extent that the risk of exposure through these pathways could be reduced by the proposed regulation, benefits will be undercounted.

In addition to these exclusions, there are a number of additional limitations to the overall analysis. Most of these limitations are specific to each disposal practice and will be discussed in the relevant sections on risk assessment and benefits analysis for each disposal method. A few generic limitations may, however, affect the risk calculations for all disposal methods. These limitations are highlighted below.

First, sludge quality data were limited. The data were taken from the 40-City Study conducted by EPA in 1981. Sludge quality most likely has changed considerably during the interim. For example, a number of categorical pretreatment standards that could result in lower sludge pollutant concentrations have been promulgated. Conversely, the hazardous waste regulations have been strengthened, which could lead to more sewer discharges and, consequently, higher sludge pollutant concentrations. EPA's survey of sludge quality, which will be initiated in 1988, should provide a more reliable data base for future analyses.

Second, the assignment of POTWs to sludge quality classifications based on the industrial component of wastewater flow is problematic. Although the percent industrial flow appears to be a reasonable indicator of the concentrations of sludge contaminants, in fact, evidence suggests this relationship is weak. Additionally, some plants have very high concentrations of one constituent, but relatively low concentrations of others. This fact suggests that a methodology assigning a representative profile of sludge constituent concentrations to a category of overall sludge quality may be flawed. For now, however, no better method has been developed.

Third, and most importantly, the analysis has been based on the assumption that sludge constituent concentrations are highly correlated, i.e., that if one constituent is present at high concentrations, the other constituents are also found in relatively high concentrations. This assumption leads to a further assumption that the highest concentrations of all constituents will be found in the sludge of a very small number of POTWs, an assumption that appears to be false. This assumption causes problems in estimating the number of plants likely to be affected by the regulation as well as in estimating average concentrations of pollutants in sludge. If, as is suspected, concentrations of sludge contaminants are not well correlated, i.e., that many POTWs could have high concentrations of just one or two pollutants, the average concentration of constituents of concern would be lower and the number of plants affected by the regulations would be significantly greater than currently estimated.

In addition to the major concerns addressed above, several other problems are inherent in the analysis.

First, the number of plants using a particular disposal practice is uncertain. Although the Needs Survey provides some information, it often lacks the necessary detail to predict risks. For example, the survey does not establish the number of facilities employing the various land application end uses such as agricultural land application or land reclamation. The analysis also does not account for new facilities or recent shifts in disposal practices. EPA's 1988-89 survey of sludge generators should provide a more accurate indication of current practices.

Second, the population exposure estimates are generally limited since population growth or mobility is not considered. Other behavior aspects of exposure, such as time spent indoors versus outdoors, are also not considered. Moreover, timing of the exposure is not considered. This last factor is especially relevant in the analysis of monofills, where exposure may not occur for 100 years or more. Studies providing improved estimates of population exposure are, however, currently underway.

Despite these uncertainties, the approach used in this analysis provides a framework that can relate regulatory action to environmental benefit. The use of sophisticated analytical tools and the access to the "best" data bases available ensure that the risk calculations presented in this RIA represent state-of-the-art predictions of human health risk.

6.3 Risk Assessment and Benefits Analysis for the Five Sludge Disposal Practices

6.3.1 Incineration

This section estimates the baseline risks and benefits resulting from controlling the exposure of human populations to contaminants from sludge incineration. The first step in this process is to describe the methods for estimating exposures to these contaminants. The following discussion provides an overview of the methodology, including how POTWs are allocated to 10 model incinerators, the key pathway of exposure considered, the fate and transport models and input parameters used, and the total population exposed. Following the discussion of the methodology, the baseline risks of incineration and the benefits of controlling incinerator emissions are presented.

Analytical Methodology

Incineration of municipal sewage sludge produces pollutant emissions that can result in human exposure through a number of different pathways. The most obvious route of exposure and the only pathway considered in this study is the inhalation of pollutants emitted to the atmosphere. Several other routes of exposure not addressed in this study can also result in exposure to contaminants from sludge incineration. These routes include deposition of pollutants on food-chain agriculture land and surface waters; the disposal of incinerator fly ash and bottom ash in landfills; and the disposal of scrubber waters. Each of these pathways can lead to additional baseline risks and subsequent benefits of control, but these additional risks and benefits are not considered in this study.

To predict exposure and risk, the analysis combined site-specific POTW data on volume of sludge incinerated at each facility with generic sludge quality data (three pollutant concentration profiles based on industrial contribution to the POTW) and the parameters of 10 model incinerator facilities that provide ranges of dispersion characteristics.

There are 169 POTWs incinerating approximately 1.7 million dry tons of sludge annually in the United States. These POTWs, which operate 282 incinerators, were assigned to 10 model facilities based on six variables, including land use (urban, rural); volume of sludge incinerated; percentage of POTW inflow from industrial sources; stack height; volume of gas flow; and temperature of gas flow at the stack. Each POTW was also distinguished by size class and furnace type. These assignments (excluding furnace type) were presented in Section Four, Table 4-2.

Additionally, there are 25 POTWs, generating 0.4 million dry tons of sewage sludge, that are currently using ocean disposal. Because of recently enacted legislation banning all ocean disposal of sewage sludge, these POTWs will have to shift to alternative methods. Incineration appears to be one of the likeliest disposal methods to be chosen by these 25 POTWs. It is by no means certain that all these POTWs will choose to incinerate their sludge; however, the ocean ban legislation is so recent that many POTWs do not even have preliminary plans in place. For analytical purposes, therefore, it has been assumed that all 25 POTWs will incinerate their sludge. This scenario is considered baseline practices for these POTWs. As such, the risks of incinerating the sludge generated by the 25 POTWs have been included in the baseline risks of incineration.

The 25 ocean ban POTWs were also assigned to model facilities. Table 4-3 in Section Four presents these assignments along with the numbers of incinerators of each type that might be built to accomodate the volumes of sludge generated by these POTWs.

EPA-approved fate and transport models were applied to the incineration inhalation pathway. The models selected were documented in EPA's Sludge Incinerator Air Quality Modeling. The primary model, used to predict chemical concentration patterns, was the Industrial Source Complex Long-Term (ISCLT) model. This model accounts for building down wash in predicting dispersion effects. The model does not, however, include the effects of dispersion in areas of "complex terrain," that is, terrain surrounding the facility at elevations greater than the facility stack height. To include the complex terrain effects in the modeling analysis, two additional dispersion models were used. The LONGZ model was used for urban areas and the COMPLEX I model was used for rural areas. The fate and transport models were run for the 10 model incinerator facilities and provided concentrations at 16 distances, from 0.5 kilometers to 50 kilometers.

Population data for each of the 169 existing facilities and the 25 ocean ban facilities were generated using the Human Exposure Model (HEM), which incorporates 1980 census data. Based on the coordinates of the incinerating

POTW, HEM provided location-specific population density data at varying distances from each facility. In this way the number of persons exposed to the concentrations predicted by the fate and transport model at various locations and distances around the facilities could be estimated.

Baseline Incineration Risks

To calculate baseline risk from exposure to the inorganic (metal) constituents of incinerated sludge, the analysis assumed that all existing incineration facilities were equipped with a scrubber. Emissions data were modeled for the baseline risk analysis using the scrubber removal efficiencies presented in Table 6-3. Additionally, the incinerators projected to be built by the ocean ban POTWs are assumed to be equipped with wet ESPs or fabric filters. Removal efficiencies of these devices are presented later in this section.

A different approach was used to estimate organic emissions. Certain organic compounds are formed during the sludge combustion process and may not be identified or may not even exist in the sludge itself. These modeled products of incomplete combustion (PICs) account for most of the constituents of total hydrocarbons as defined in the proposed sludge incineration regulations. It is thus more appropriate to begin the analysis by estimating an emission rate for organics, rather than by starting with a sludge concentration and modeling a scrubber removal efficiency. To estimate organic emissions from sludge incinerators, data from a study of four incinerators was analyzed.[10] Hydrocarbon emission rates estimated to be associated with fluid-bed and multiple-hearth furnaces are presented in Table 6-4.

The results of the baseline risk analyses for incineration are depicted in Tables 6-5 and 6-6, which present risks for contaminants exhibiting carcinogenic effects and for those exhibiting noncarcinogenic effects, respectively. The baseline number of cancer cases attributed to current sludge incineration practices totals 13 cases per year. Nearly 6,000 cases of noncancer illness per year are estimated to be attributable to sludge

TABLE 6-3

CONTAMINANT REMOVAL EFFICIENCIESY OF MUNICIPAL SLUDGE INCINERATORS (%)

CHEMICAL	BASELINE OPTION
Arsenic	96.96
Beryllium	99.99
Cadmium	74.61
Chromium	97.53
Lead	77.01
Mercury	0.00
Nickel	96.71

Source: Abt Associates estimates.

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TABLE 6-4

EMISSION RATES FOR ORGANICS BY FURNACE TYPE
(Grams/Second per Dry Metric Ton of Sludge Incinerated Per Second)[a]

CONTAMINANT	FLUID-BED[b]	MULTIPLE-HEARTH[c]
* Acetonitrile	2.53E-03	4.79E+00
2,4 Dichlorophenol	5.47E-02	2.22E+00
2,4 Dinitrophenol	1.00E+00	1.46E+01
* Methyl ethyl ketone	2.53E-03	2.98E-02
Pentachlorophenol	2.19E-01	4.32E+00
Phenol	2.74E-02	2.30E+00
1,2,4-Trichlorobenzene	4.10E-02	8.81E-03
Toluene	9.63E-02	9.66E+00
* Acrylamide	2.53E-03	6.66E-03
Acrylonitrile	4.66E-02	2.89E+01
Aldrin	5.47E-02	9.72E+00
* Aniline	2.53E-03	6.66E-03
* Benzo(a)anthracene	2.53E-03	6.66E-03
Benzene	5.83E-01	2.23E+01
* Benzidine	2.53E-03	6.66E-03
Benzo(a)pyrene	4.10E-02	9.77E-01
* Bis(2-chlorethyl)ether	2.53E-03	6.66E-03
* Bis(chloromethyl)ether	2.53E-03	6.66E-03
Bis(2-ethylhexyl)phthalate	3.88E-01	2.19E+00
* 1,3-Butadiene	2.53E-03	6.66E-03
Carbon tetrachloride	2.03E-02	1.15E-01
Chlordane	8.21E-01	3.34E-01
Chloroform	5.65E+00	5.28E+00
* Chloromethane	2.53E-03	6.66E-03
* Chlormethyl methyl ether	2.53E-03	6.66E-03
* DDT	2.53E-03	6.66E-03
* Dibenzo(a,h)anthracene	2.53E-03	6.66E-03
* 1,2-Dibromo-3-chloropropane	2.53E-03	6.66E-03
* 1,2-Dibromoethane	2.53E-03	6.66E-03

TABLE 6-4 (CONT.)

CONTAMINANT	FLUID-BED[b]	MULTIPLE-HEARTH[c]
1,2-Dichloroethane	7.85E-03	3.76E-02
* 1,1-Dichloroethylene	2.53E-03	6.66E-03
Dieldrin	8.21E-02	8.80E+00
* Diethylstilbestrol	2.53E-03	6.66E-03
* 2,4-Dinitrotoluene	2.53E-03	6.66E-03
* Dioxane	2.53E-03	6.66E-03
* 1,2-Diphenylhydrazine	2.53E-03	6.66E-03
* Epichlorohydrin	2.53E-03	6.66E-03
* Ethylene oxide	2.53E-03	6.66E-03
* Formaldehyde	2.53E-03	6.66E-03
* Heptachlor	2.53E-03	6.66E-03
* Heptachlor epoxide	2.53E-03	6.66E-03
* 2,3,7,8-Heptachlorodibenzo-p-dioxin	2.53E-03	5.94E-03
* other-Heptachlorodibenzo-p-dioxin	2.53E-03	6.66E-03
* Hexachlorobenzene	2.53E-03	6.66E-03
* Hexachlorobutadiene	2.53E-03	6.66E-03
* alpha-Hexachlorocyclohexane	2.53E-03	6.66E-03
* beta-Hexachlorocyclohexane	2.53E-03	6.66E-03
* gamma-Hexachlorocyclohexane	2.53E-03	6.66E-03
* Hexachlorocyclohexane, technical	2.53E-03	6.66E-03
* 2,3,7,8-Hexachlorodibenzo-p-dioxin	2.53E-03	6.66E-03
* other-Hexachlorodibenzo-p-dioxin	2.53E-03	5.94E-03
* Hexachloroethane	2.53E-03	6.66E-03
* 3-Methylcholanthrene	2.53E-03	6.66E-03
Methylene chloride	1.04E-01	4.16E-01
* 4,4-Methylene-bis-2-chloroaniline	2.53E-03	6.66E-03
* Methyl hydrazine	2.53E-03	6.66E-03
* 2-Nitropropane	2.53E-03	6.66E-03
* N-Nitrosodi-N-butylamine	2.53E-03	6.66E-03
* N-Nitrosodiethylamine	2.53E-03	6.66E-03
* N-Nitrosodimethylamine	2.53E-03	6.66E-03

TABLE 6-4 (CONT.)

CONTAMINANT	FLUID-BED[b]	MULTIPLE HEARTH[c]
* N-Nitrosopyrrolidine	2.53E-03	6.66E-03
PCBs	8.91E-01	1.97E-01
* 2,3,7,8-pentachlorodibenzo-p-dioxin	2.53E-03	6.66E-03
* other-pentachlorodibenzo-p-dioxin	2.53E-03	5.94E-03
* Pentachloronitrobenzene	2.53E-03	6.66E-03
* Pronamide	2.53E-03	6.66E-03
* Reserpine	2.53E-03	6.66E-03
* 2,3,7,8-Tetrachlorodibenzofuran	2.53E-03	5.94E-03
* 2,3,7,8-Tetrachlorodibenzo-p-dioxin	2.53E-03	5.94E-03
* other-Tetrachlorodibenzo-p-dioxin	2.53E-03	5.95E-03
* 1,1,1,2,-Tetrachloroethane	2.53E-03	6.66E-03
Tetrachloroethylene	2.18E-01	1.44E+01
* Thiourea	2.53E-03	6.66E-03
* Toxaphene	2.53E-03	6.66E-03
* 1,1,2-Trichloroethane	2.53E-03	6.66E-03
Trichloroethylene	1.52E-02	2.17E+00
2,4,6,-Trichlorophenol	8.23E-02	3.00E+00
Vinyl chloride	2.28E-02	8.33E+00

*Chemical was neither reported nor detected: Model assumes 0.1 ng/l flue gas concentration.

[a] Emission rates were derived from a database of parameters reported in the four sludge incinerator studies referenced below. Since the model needed emission per unit of sludge, chemical concentrations in the flue gas were related to the volume of sludge incinerated at each test site.

[b] Emission rates were derived by analyzing results from the study of a sludge incinerator equipped with a fluid-bed furnace.

[c] Emission rates were derived by analyzing results from the study of three sludge incinerators equipped with multiple-hearth furnaces.

Source: Abt Associates estimates based on source (10).

TABLE 6-5

BASELINE RISKS OF SEWAGE SLUDGE INCINERATION TO AGGREGATE POPULATIONS

CONTAMINANT	WEIGHT OF EVIDENCE	ANNUAL NUMBER OF CANCER CASES
Arsenic	A	0.17
Beryllium	B2	<0.01
Cadmium	B1	3.3
Chromium	A	0.26
Nickel	A	0.28
Acrylonitrile	B1	0.98
Aldrin	B2	0.02
Benzene	A	0.09
Benzidine	A	0.26
Benzo(a)pyrene	B2	1.52
Bis(chloromethyl)ether	—	0.25
Chlordane	B2	0.15
Chloroform	B2	0.10
Chloromethane	—	0.01
Chloromethyl methyl ether	A	0.01
Dibenzo(a,b)anthracene	—	0.06
1,2-Dibromo-3-chloropropane	—	0.05
Dieldrin	B2	0.01
Diethylstilbestrol	—	0.56
Heptachlor epoxide	B2	0.01
2,3,7,8 Hexachloro-dibenzo-p-dioxin	B2	0.01
3-Methylcholanthrene	—	0.01
2-Nitropropane	—	0.25
N-Nitrosodiethylamine	B2	0.17
N-Nitrosodimethylamine	B2	0.06
PCBs	B2	0.76
2,3,7,8-Pentachlorodibenzo-p-dioxin	—	0.29
Reserpine	—	0.01
2,3,7,8-Tetrachlorodibenzofuran	—	0.08
2,3,7,8-Tetrachlorodibenzo-p-dioxin	B2	0.02
Other tetrachlorodibenzo-p-dizoin	B2	0.02
Tetrachloroethylene	B2	0.10
Vinyl chloride	A	2.70
Total		13

Note: In most cases, pollutants associated with less than 0.01 cases annually have been omitted from this table. See Abt Associates report, Human Health Risk Assessment for Municipal Sludge Disposal Benefits of Alternative Regulatory Options, Draft, for more detail.

Source: Abt Associates estimates.

TABLE 6-6

BASELINE RISKS OF SEWAGE SLUGE INCINERATORS (NONCARCINOGENIC EFFECTS)

EXPOSED POPULATION	EXPECTED DISEASE CASES[a]
Men	4,030
Women	864
Children	1,081
Total	5,976

[a] Disease cases are attributable to lead. Totals may not add due to rounding.

Source: Abt Associates estimates.

2139S

incineration. All are associated with lead emissions. The most exposed individual faces a risk of cancer from inhaling incinerator emissions of $5x10^{-2}$. Aldrin is the contaminant with the highest contribution to this risk.

Benefits of Controls on Sludge Incineration

To calculate the benefits of the proposed regulations, the analysis assumed that POTWs failing to meet the proposed incineration criteria would retrofit additional control devices on their existing incinerators. Three basic control strategies were assumed to be used to control pollutants. The first strategy involves the installation of wet electrostatic precipitators (ESPs) or fabric filters to reduce metal emissions. The second involves the installation of dry scrubbers in combination with fabric filters. An additional strategy involves the installation of afterburners to control hydrocarbon emissions. Wet ESPs and afterburners were chosen for further analysis and are the basis for calculating the benefits of the proposed regulation. The increase in pollutant removals (the removal efficiencies) for these devices as well as for fabric filters and dry scrubbers with fabric filters was developed by reviewing the available literature. These removal efficiencies are presented in Table 6-7.

The benefits, presented as risk reductions, are shown in Table 6-8. This table also presents the reduction in the number of people expected to exhibit health effects due to exposure to lead concentrations above the lead threshold. The results indicate that the addition of wet ESPs and afterburners reduces the number of cancer cases per year by 9.6 cases and correspondingly reduces the number of expected disease cases from lead exposure by about 5,217 cases per year in Options 3 and 4. Where only wet ESPs are added (in Options 1 and 2), about 2.8 cancer cases and 5,155 noncancer cases are avoided annually.

TABLE 6-7

REMOVAL EFFICIENCIES FOR EACH OF THE POLLUTION CONTROL DEVICES CONSIDERED FOR RETROFITTING TO SEWAGE SLUDGE INCINERATORS (%)

POLLUTANT	WET ESPS/ FABRIC FILTERS	DRY SCRUB-BERS WITH FABRIC FILTERS	WET ESPs AND AFTERBURNERS
Arsenic	98.36	99.90	98.36
Beryllium	99.99	99.90	99.99
Cadmium	94.02	99.90	94.02
Chromium	99.16	99.90	99.16
Lead	97.60	99.90	97.60
Mercury	0.0	91.00	0.0
Nickel	98.68	99.90	98.68
Trace Organics	0.0	0.0	98.00
Dioxins	0.0	0.0	99.00
Furans	0.0	0.0	99.00

Source: Abt Associates estimate.

2153S

TABLE 6-8

THE BENEFITS OF CONTROLLING EMISSIONS FROM SEWAGE SLUDGE INCINERATORS MEASURED AS REDUCTIONS IN HUMAN HEALTH RISKS

	REDUCTIONS IN NUMBER OF DISEASE CASES			
HEALTH EFFECT	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Cancer	2.8	2.8	9.6	9.6
Noncancer				
Men	3,365	3,365	3,418	3,418
Women	790	790	795	795
Children	1,000	1,000	1,005	1,005
Total	5,155	5,155	5,217	5,217

Source: Abt Associates estimates.

2154S

Additional risks and benefits of incineration will be realized, however. Other POTWs now practicing a variety of sludge disposal methods are expected to choose incineration as a compliance strategy under the proposed regulations. The net benefits of these POTWs shifting to incineration are shown in Table 6-9. Note that in most cases net benefits of the shift are negative (i.e., the risks associated with the current disposal practice are less than the risks associated with incinerating the sludge). Thus, benefits under Options 1 and 2 remain the same (since no POTWs shift to incineration under these options) while benefits under Options 3 and 4 drop to a total of 9.4 and 7.3 cancer cases avoided and a total of 5,155 and 4,759 noncancer cases avoided, respectively. Note that the ocean ban POTWs do not contribute to these benefits. These POTWs are not expected to require additional pollution control devices on their incinerators, thus the baseline risk of incinerating sludge generated by these POTWs will not change.

6.3.2 Sludge Monofilling

This section presents the baseline risks and benefits of regulatory controls on sludge landfilling. Since the Office of Solid Waste is planning to control the codisposal of sewage sludge with municipal solid waste, which accounts for 95 percent of landfilled sludge, this section focuses only on those facilities which dispose of sludge in monofills. Forty-nine POTWs, generating 101,000 dry metric tons of sludge per year, currently use this disposal method. The section below describes the critical exposure pathways considered, the fate and transport models and assumptions used, and the methods used to assess exposed populations.

Analytical Methodology

The primary routes of exposure from sludge monofills include vapor loss, resuspension of particulates, runoff, and leachate migration to ground water. This study considers the leaching of sludge contaminants to ground water and estimates the human health risks from consuming drinking water from

TABLE 6-9

BENEFITS OF SHIFTING SLUDGE TO INCINERATION FROM OTHER DISPOSAL METHODS

	REDUCTION IN DISEASE CASES							
	OPTION 1		OPTION 2		OPTION 3		OPTION 4	
	TOTAL REDUCTION	NET BENEFIT	TOTAL REDUCTION	NET BENEFIT	TOTAL REDUCTION	NET BENEFIT	TOTAL REDUCTION	NET BENEFIT
Cancer	0	2.8	0	2.8	-0.23	9.4	-2.3	7.3
Noncancer								
Men	0	3,365	0	3,365	-43	3,375	-371	3,047
Women	0	790	0	790	-5	790	-42	753
Children	0	1,000	0	1,000	-6	999	-46	954
Total	0	5,155	0	5,155	-54	5,163	-458	4,759

Note: Negative figures show an increase in risk associated with shifts from other disposal methods to incineration.

Source: Abt Associates estimates.

contaminated ground water. The study also considers vapor loss and the resuspension of particulates, with subsequent inhalation of contaminated air by residents downwind of the site. Surface water runoff is assumed to be controlled by following proper design as described in EPA's Sludge Landfill Design document.

Fate and transport of contaminants from sludge monofills to ground water and transport in ground water was modeled using SLUDGEMAN. SLUDGEMAN links three existing models, the CHAIN model to simulate unsaturated zone transport, MINTEQ to simulate geochemical reactions of metals in ground water, and AT123 to predict ground water transport. In general, SLUDGEMAN simulates migration of contaminants from the fill area of the monofill through the unsaturated soil column into the aquifer and then laterally through the saturated zone. This procedure results in an estimate of pollutant concentrations at monitoring boundary points. This estimate can be used to represent the concentrations of drinking water contaminants in wells near sludge monofills. To model the vapor pathway, SLUDGEMAN's vapor component was used to compute downwind air concentrations from 150 meters to 10 kilometers.

The study estimates affected populations for the vapor pathway using Census data to identify populations between 150 meters and 10 km and for the ground water pathway using data from the Federal Reporting Data System (FRDS) and state and regional authorities on the location and population served by drinking water wells near monofills. The contaminated plume is assumed as the area inside a 90 degree arc centered at the direction of ground water flow, within 4 kilometers of the landfill. For all contaminants except lead, a 95th percentile drinking water consumption rate of 2 liters per day is assumed. For lead, the population is disaggregated by sex and age groups. Adults are assumed to consume 2 liters of water per day and children under 7 years are assumed to consume 1 liter of water per day. Background concentrations are assumed homogeneous throughout the aquifer.

Baseline Monofill Risks

The baseline risk assessment results are presented in Tables 6-10 and 6-11. These tables present total risk results for both the aggregate population and the maximum exposed individual and also delineate risks by the vapor and ground water pathways. Risks from carcinogenic and noncarcinogenic constituents are presented separately.

Dimethylnitrosamine from the vapor pathway and benzene from the ground water pathway appear to contribute the most to baseline cancer risk to the maximum exposed individual from sludge monofill disposal practices. Although the risks of cancer to the maximum exposed individual are relatively high (3×10^{-5} ground water, and 3×10^{-3} vapor), the risks to the total population from carcinogenic compounds appear to be minimal (about 0.02 cancer cases per year). Among the contaminants associated with noncarcinogenic effects, only lead appears to exhibit adverse health effects. An estimated 26 cases of noncancer are estimated to occur annually under current monofill disposal practices.

Benefits of Controlling Sludge Monofills

Section Four of this report describes the compliance strategies for those sludge monofills which do not meet the proposed criteria. This analysis assumes that the POTWs whose sludge fails to meet the monofilling criteria shift to codisposal, incineration, or composting with monofilling as alternative disposal practices. Sludge monofills are not assumed to be required to meet the upcoming RCRA Subtitle D regulations for municipal landfills. As a result, the benefits of the proposed sewage sludge regulations are measured as the reduction in risk accompaning the shift in disposal practices. No reduction in risk has been calculated for sludges that continue to be monofilled following composting since the effects of composting on monofill risks could not be estimated.

TABLE 6-10

BASELINE RISKS OF SEWAGE SLUDGE MONOFILLING TO AGGREGATE POPULATIONS

CONTAMINANT	WEIGHT OF EVIDENCE	ANNUAL NUMBER OF CANCER CASES		
		GROUND WATER	VAPOR	TOTAL
Benzene	A	1×10^{-3}	4×10^{-4}	1×10^{-3}
Benzo(a)pyrene	B2	3×10^{-5}	3×10^{-3}	3×10^{-5}
Chlordane	B2	6×10^{-4}	2×10^{-6}	6×10^{-4}
DEHP	B2	2×10^{-5}	--	2×10^{-5}
DDT	B2	--	--	--
Dimethylnitrosamine	B2	--	2×10^{-2}	2×10^{-2}
Lindane	B2	--	--	--
PCBs	B2	4×10^{-7}	8×10^{-8}	5×10^{-7}
TCE	B2	--	9×10^{-4}	9×10^{-4}
Toxaphene	B2	2×10^{-5}	4×10^{-5}	2×10^{-2}
Total		0.002	0.02	0.02

Source: Abt Associates estimates.

TABLE 6-11

BASELINE RISKS OF SEWAGE SLUDGE MONOFILLING (NONCARCINOGENIC EFFECTS)

	NUMBER OF DISEASE CASES		
POPULATION	GROUND WATER	VAPOR	TOTAL
Men	11	0	11
Women	1	0	1
Children	14	0	14
Total	26	0	26

Source: Abt Associates estimates.

Table 6-12 presents the results of the analysis. As the table shows, less than 0.01 cancer cases and no noncancer cases will be avoided annually under the Option 2 scenario, while an estimated 0.02 cancer cases and 26 noncancer cases will be avoided annually under the Option 3 and 4 scenarios. (Option 1 has no impact on risks or benefits.)

6.3.3 Land Application

Approximately 1.2 million dry metric tons of municipal sewage sludge are land applied each year, representing about 16 percent of national sludge production. Sludge is applied to a variety of land types, including agricultural land; and nonagricultural land such as dedicated sites, forests, roadsides, nurseries and reclaimed land. This analysis considers dietary, surface water, and ground water pathways. The sections below present the methodology for assessing human health risks and benefits, including the critical routes of exposure, the fate and transport models and key inputs, and the approach to estimating populations.

Analytical Methodology

For sewage sludge applied to agricultural land, three dietary pathways of exposure are analyzed. These include: (1) human consumption of crops grown on sludge-amended soil; (2) human consumption of meat and dairy products from animals that have ingested feed or pasture grasses grown on sludge-amended soils; and (3) human consumption of beef, dairy products or lamb from animals that directly ingest sludge from pasture grasses. Agricultural land application, as well as nonagricultural land application, is associated with two additional pathways of exposure: human consumption of drinking water from contaminated ground water and surface water sources and the consumption of fish and shellfish from contaminated surface water.

TABLE 6-12

BENEFITS OF CONTROLLING SLUDGE MONOFILLS MEASURED AS REDUCTION IN HUMAN HEALTH RISKS[a]

	REDUCTIONS IN DISEASE CASES	
	OPTION 2	OPTIONS 3 AND 4
Cancer	<0.01	0.02
Noncancer		
Men	0	11
Women	0	1
Children	0	14
Total	0	26

[a] Positive benefits reflect reduction in the number of cases; negative benefits reflect an increase of cases.

Source: Abt Associates estimates.

The methodologies used to assess human dietary exposure and risk from agricultural land application have been compiled and computerized in a software program that runs on an IBM PC. The model takes a number of key factors as inputs, including:

- Application rates of sludge to particular crops.
- Levels of concentration of sludge constituents.
- Rates at which crops absorb contaminants from the soil into their tissues.
- Rates at which contaminants in animal feeds are absorbed into meat and dairy products.
- Mix of feeds in livestock diets.
- Distribution and mixing of harvested crops before consumption.
- Dietary consumption patterns for the nation as a whole (for aggregate population risk) and for individual demographic groups (for MEI risk).
- Fraction of national production of each crop, meat or dairy product affected by land application of sludge.
- Conservation of metals and organic contaminants in the soil.

For the ground water and surface water pathways, the analysis relied on other methodologies. For the surface water pathway, the long-term concentrations of contaminants in sludge-amended soil are calculated for all the land application practices and for the three sludge quality profiles; and transport of soil and contaminants by erosion is estimated to determine the contaminant loadings to surface water. Human ingestion of contaminants is then calculated based on assumptions of drinking water and freshwater fish consumption. The appropriate concentations of sludge contaminants, the amount of land application activity, the size of exposed populations and the amount of surface water are used as inputs to the model. Results are aggregated to produce a risk estimate (cancer and noncancer) for each contaminant. For the ground water pathway, ECAO's SLAPMAN model was used to predict concentrations of contaminants in ground water resulting from applying sludge to forest land, dedicated land and reclaimed land. Certain components of the SLUDGEMAN model were also used to simulate transport of contaminants to drinking water wells.

To estimate populations exposed to contaminants from sludge-amended agricultural land, EPA's Office of Pesticide Program's Tolerance Assessment System (TAS) dietary data base was used. This source provides statistics on average daily consumption of the food groups chosen for inclusion in this analysis. For nonagricultural land application, numbers of persons consuming ground water were obtained from NWWA's WELLFAX data base. This approach is similar to that taken to determine the ground water pathway from monofills. The analysis of the surface water pathway relied on the Office of Drinking Water's FRDS data base to determine the number of individuals consuming drinking water from public systems served by surface water.

Baseline Land Application Risks

This section presents baseline risks from the land application of sludge. Table 6-13 presents the annual baseline carcinogenic risks to aggregate populations from agricultural land application through dietary pathways. Table 6-14 presents cases of noncancer expected through dietary exposure to the contaminants of concern.

A total of 0.17 cancer cases per year is estimated to be attributable to the dietary pathway. The risk to the maximum exposed individual is estimated to be 9×10^{-5}. Hexachlorobenzene is estimatd to contribute the greatest portion of this risk to the most exposed individual. Only lead is expected to have any associated noncarcinogenic health effects; a total of 38 noncancer disease cases are estimated to occur through the dietary pathway.

Table 6-15 displays the annual baseline risks from carcinogens to aggregate populations for the ground water and surface water pathways. A total of 0.01 cancer cases are expected each year due to current land application practices. The risk to the most exposed individual is 1.0×10^{-3}, with BEHP as the contaminant with the greatest contribution to total MEI cancer risk. Table 6-16 presents the baseline risk from noncarcinogens through the groundwater and surface water pathways. A total of 2.5 cases of noncancer, associated with lead exposure, are expected to occur annually.

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TABLE 6-13

BASELINE RISKS OF AGRICULTURAL LAND APPLICATION OF SEWAGE SLUDGE TO AGGREGATE POPULATIONS: DIETARY PATHWAY

CONTAMINANT	WEIGHT OF EVIDENCE	ANNUAL NUMBER OF CANCER CASES
Aldrin	B2	0.04
Benzo(a)pyrene	B2	0.02
Chlordane	B2	<0.01
DDT	B2	<0.01
Heptachlor	B2	0.01
Hexachlorobenzene	B2	0.08
Hexachlorobutadiene	C	<0.01
Lindane	B2	<0.01
PCBs	B2	<0.01
Toxaphene	B2	<0.01
Total		0.17

Source: Abt Associates estimates.

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TABLE 6-14

BASELINE RISKS OF AGRICULTURAL LAND APPLICATION OF SEWAGE SLUDGE (NONCARCINOGENIC EFFECTS): DIETARY PATHWAY

POPULATION	EXPECTED DISEASE CASES
Men	32
Women	2.8
Children	3.3
Total	38

Source: Abt Associates estimates.

TABLE 6-15

BASELINE RISKS OF AGRICULTURAL AND NONAGRICULTURAL LAND APPLICATION OF SEWAGE SLUDGE TO AGGREGATE POPULATIONS: GROUND WATER AND SURFACE WATER PATHWAYS

CONTAMINANT	WEIGHT OF EVIDENCE	ANNUAL NUMBER OF CANCER CASES	
		SURFACE WATER	GROUND WATER
Aldrin/Dieldrin	B2	<0.01	—
BEHP	B2	—	<0.01
Benzene	A	—	<0.01
Benzo(a)pyrene	B2	<0.01	<0.01
Chlordane	B2	<0.01	<0.01
DDT	B2	<0.01	<0.01
DMN	B2	<0.01	<0.01
Heptachlor	B2	<0.01	--
Hexachlorobenzene	B2	<0.01	—
Hexachlorobutadiene	C	<0.01	—
Lindane	B2	<0.01	<0.01
PCBs	B2	<0.01	<0.01
Toxaphene	B2	<0.01	<0.01
TCE	B2	<0.01	<0.01
Total		<0.01	0.01

Source: Abt Associates estimates.

2157S

TABLE 6-16

BASELINE RISKS OF AGRICULTURAL AND NONAGRICULTURAL LAND APPLICATION OF SEWAGE SLUDGE (NONCARCINOGENIC EFFECTS): GROUND WATER AND SURFACE WATER PATHWAYS

POPULATION	NO. OF DISEASE CASES EXPECTED
Men	1.7
Women	0.15
Children	0.61
Total	2.5

Source: Abt Associates estimates.

2159S

Virtually all the risks of noncancer and much of the risks of cancer are associated with the dedicated land application option. Agricultural land application contributes half the cancer risk to the total cancer risk for the nondietary pathways.

Total baseline risks of land application through all pathways analyzed are 0.18 cancer cases and 41.5 noncancer cases annually.

Benefits of Controls on Land Application

Section Four examines land application practices in detail and indicates the number of facilities that are predicted to fail the proposed sludge criteria. The compliance strategies and the derivation of the number of plants selecting alternatives for this pathway are complex. For the most part, it is assumed that those POTWs which cannot meet the criteria will select another disposal option. The alternative options that are used in this analysis are presented in Section Four.

The benefits of these proposed regulations are measured as the reduction in risk that accompanies shifts in disposal practices. Table 6-17 presents the results of this analysis. Note that benefits become negative under Option 3, since sludge currently being applied to agricultural land and disposed through distribution and marketing is expected to shift to nonagricultural land application. As these tables show, under all options, far fewer than one cancer case is averted annually by controlling either agricultural or nonagricultural land application. For agricultural land application, the greatest declines in noncancer risks are achieved: 4.5 to 41 noncancer cases are expected to be averted each year, depending on regulatory option. Reductions in numbers of noncancers resulting from controls on nonagricultural land application range from -7 to 1.4 cases annually. The number of cancer cases avoided annually for all land application disposal methods total 0.06 for Options 2 and 3 and and 0.18 Option 4. The number of noncancer cases avoided annually total 4 for Option 2, 21 for Option 3, and 42 for Option 4. No additional risks or benefits are associated with Option 1.

TABLE 6-17

BENEFITS OF CONTROLLING AGRICULTURAL AND NONAGRICULTURAL LAND APPLICATION MEASURED AS REDUCTIONS IN HUMAN HEALTH RISKS[a]

CONTAMINANT	REDUCTIONS IN NUMBERS OF CANCER CASES	REDUCTIONS IN NUMBERS OF NONCANCER CASES
	OPTION 2	
Agriculture	0.05	4.6
Nonagriculture	<0.01	-0.55
Total	0.06	4
	OPTION 3	
Agriculture	0.15	28
Nonagriculture	-0.09	-6.8
Total	0.06	21
	OPTION 4	
Agriculture	0.17	41
Nonagriculture	0.01	1.4
Total	0.18	42

[a] Positive benefits reflect reductions in the number of cases; negative benefits reflect an increase of cases.

Source: Abt Associates estimates.

6.3.4 Distribution and Marketing

Approximately 700,000 dry metric tons of composted or heat-stabilized sludge are sold or given away each year in the United States. As with land application, the distribution and marketing of sludge involves the conversion of a waste product to a useful resource, but may present human health risks through several pathways. This analysis considers several uses of distributed and marketed sludge, including use in home gardens and on lawns and shrubbery. The following sections describe the methods and examine the results of the risk assessment and benefits analysis.

Analytical Methodology

The analysis examined the following routes of exposure from the distribution and marketing of sludge:

- Distributed and/or marketed sludge is acquired by home owners, who apply the compost to their home vegetable gardens. Contaminants in the sludge enter the tissues of home-grown produce, which are then consumed by the gardening household.
- Distributed or marketed sludge compost is acquired by home owners, who apply the sludge to gardens, lawns, or shrubbery. Young children in the gardening household ingest small quantities of the sludge directly, through "pica" behavior, the ingestion of nonfood items.
- Distributed or marketed sludge is applied to nonresidential land. Treated soil then erodes into nearby streams and lakes. Humans drink water from these surface water sources.
- Distributed and marketed sludge is applied to nonresidential land. Sludge contaminants leach into ground water. Humans drink water from ground water supplies.

As for the land application analysis, the key inputs to the model include application rates; concentration of sludge constituents; uptake rates for crops; conservation of metals in the topsoil; dietary intake; and estimates of exposed populations.

The calculations differ from land application in the following respects:

- No meat or dairy products are assumed to be produced from feeds grown in home gardens.
- No distribution of produce to national markets is assumed. The exposed population is limited to those applying composted sludge to their home gardens.
- Children of home owners are assumed to ingest a certain amount of garden soil daily.

The most exposed individual is assumed to be a young child who lives in a household using sludge on its vegetable garden, who falls in the 95th pecentile of soil ingestion rates and who consumes home-grown vegetables at typical rates for the 1- to 6-year-old age group.

Baseline Distribution and Marketing Risks

Baseline annual aggregate population risks of cancer are presented in Table 6-18. Total cancer risk is 0.02 cancer case annually for the dietary pathway and less than 0.01 cancer cases each for the surface water for a total of 0.02 cancer cases annually. The risks to the most exposed individual are $9x10^{-5}$ through the dietary pathway. The contaminant contributing the most to this risk through the dietary pathway is benzo(a)pyrene. The risks to the most exposed individual through the surface water and ground water pathways are $1x10^{-8}$ and $1x10^{-5}$, respectively. Hexachlorobenzene is the major contributor to risk to the MEI through the surface water pathway, while benzene is the major contributor to risk through the ground water pathway. Noncancer risks are presented in Table 6-19. As shown, an estimated 95 persons are expected to develop noncancer annually, due to lead exposure through the dietary pathway. Far less than one noncancer case is attributable to exposure through the other pathways.

TABLE 6-18

BASELINE RISKS OF DISTRIBUTION AND MARKETING OF SEWAGE SLUDGE TO AGGREGATE POPULATIONS

	ANNUAL NUMBER OF CANCER CASES			
CONTAMINANT	WEIGHT OF EVIDENCE	DIETARY PATHWAY	SURFACE WATER PATHWAY	GROUND WATER PATHWAY
Aldrin/Dieldrin	B2	<0.01	<0.01	—
BEHP	B2	—	—	<0.01
Benzene	A	—	—	<0.01
Benzo(a)pyrene	B2	<0.01	<0.01	<0.01
Chlordane	B2	<0.01	<0.01	<0.01
DDT	B2	<0.01	<0.01	<0.01
DMN	B2	—	<0.01	<0.01
Heptachlor	B2	<0.01	<0.01	—
Hexachlorobenzene	B2	<0.01	<0.01	—
Hexachlorobutadiene	B2	<0.01	<0.01	—
Lindane	B2	<0.01	<0.01	<0.01
PCBs	B2	<0.01	<0.01	<0.01
Toxaphene	B2	<0.01	<0.01	<0.01
TCE	B2	—	<0.01	<0.01
Total		0.02	<0.01	<0.01

Source: Abt Associates estimates.

TABLE 6-19

BASELINE RISKS OF DISTRIBUTION AND MARKETING OF SEWAGE SLUGE (NONCARCINOGENIC EFFECTS)

	NUMBER OF DISEASE CASES EXPECTED			
POPULATION	DIETARY PATHWAY	SURFACE WATER PATHWAY	GROUND WATER PATHWAY	TOTAL
Men	52	0.20	<0.1	52
Women	4.5	0.02	<0.1	4.5
Children	38	0.07	<0.1	38
Total	95	0.28	<0.1	95

Source: Abt Associates estimates.

Benefits of Controlling the Distribution and Marketing of Sludge

Table 6-20 indicates the reductions in health risk attained when the regulatory options are implemented, as described in Section Four. Once again, POTWs are assumed to shift to alternative disposal practices to meet the proposed sludge criteria. The benefits, therefore, are measured as the reduction in risk that accompanies this shift in disposal practices. Both Option 3 and Option 4 are associated with a reduction in the number of cancer cases of 0.02 cases annually. A total of 56 and 62 cases of noncancer are avoided annually due to Options 3 and 4, respectively. Options 1 and 2 have no additional risk or benefits associated with them.

6.4 Environmental and Other Benefits

As discussed earlier, the environmental (i.e., nonhealth) benefits of controlling sludge disposal disposal could not be quantified. A qualitative discussion of these benefits is presented below.

The regulation of sewage sludge disposal is expected to result in certain environmental benefits in addition to the benefits associated with reducing the incidence of adverse human health effects. Such environmental effects are an outgrowth of the general reduction of the amount and toxicity of sludges that are disposed of, particularly that disposed in environmentally sensitive areas. These environmental benefits consist mainly of improved habitats for wildlife and other species in the areas where the disposal and use practices occur.

For example, the regulations affecting land application of sewage sludge are likely to result in some level of improvement in the quality of waterbodies in the watershed for these areas. The management practices specified in the regulation will affect soil incorporation of the sludge and provide for distance limits from waterbodies; both changes will tend to decrease runoff of pollutants, thereby improving water quality in the area's streams, ponds, or rivers. These improvements, while they may be small, will

TABLE 6-20

BENEFITS OF CONTROLLING THE DISTRIBUTION AND MARKETING OF SEWAGE SLUDGE MEASURED AS THE REDUCTION IN HUMAN HEALTH RISKS[a]

CONTAMINANT	REDUCTIONS IN NUMBERS OF CANCER CASES	REDUCTIONS IN NUMBERS OF NONCANCER CASES
	OPTION 3	
Dietary	0.02	30
Surface Water	<0.1	2.7
Ground Water	<0.1	23
Total	0.02	56
	OPTION 4	
Dietary	0.02	35
Surface Water	<0.1	3
Ground Water	<0.1	25
Total	0.02	62

[a] Positive benefits reflect reduction in the number of cases; negative benefits reflect an increase of cases.

Source: Abt Associates estimates.

2162S

nevertheless benefit the aquatic species present and other species in the food chain that are dependent on the waterbodies for food (e.g., ducks, geese). To some extent, both commercial and sport fishermen and hunters are likely to gain some benefit due to the improved habitats for fish and wildlife.

Changes in incineration practices are also likely to provide some marginal environmental gain for wildlife. In addition, emissions reductions in the vicinities of the incinerators may reduce particulate and other chemical deposition on buildings, automobiles, and structures, providing for a reduction in the extent to which these items are damaged by air pollution. Finally, commercial farms and home gardens located in deposition areas for affected sludge incinerators may experience some gain in crop vitality due to lower levels of pollutants that are discharged.

NOTES TO SECTION SIX

1. This section of the RIA was prepared by Abt Associates.

2. U.S. Environmental Protection Agency, 1983. *Guidelines for Performing Regulatory Impact Assessments*. December.

3. *Human Health Risk Assessment for Municipal Sludge Disposal: Benefits of Alternative Regulatory Options*, Office of Water Regulations and Standards, U.S. Environmental Protection Agency, July 1987. Prepared by Abt Associates, Inc., Washington, DC.

4. National Academy of Sciences, 1983. *Risk Assessment and Management: Framework for Decision-Making*, Washington, DC.

5. U.S. Environmental Protection Agency, 1986. *Guidelines for Carcinogen Risk Assessment*, 51FR33992.

6. Same as Note 4.

7. Same as Note 4.

8. U.S. Environmental Protection Agency, 1986. *Guidelines for Mutagenicity Risk Assessment*, 51FR34006.

9. U.S. Environmental Protection Agency, 1986. *Guidelines for Estimating Exposure*, 51FR34042.

10. U.S. EPA, 1987, 1988. *Site 1 Draft Emission Test Report. Sewage Sludge Test Program*, July 17, 1987; *Site 2 Draft Emission Test Report Sewage Sludge Test Program. Vol. 1, Emissions Test Results*. Oct. 19, 1987, *Site 3 Draft Emission Test Report. Sewage Sludge Test Program*, Oct. 1, 1987; *Site 4 Draft Final Emission Test Report. Sewage Sludge Test Program, Vol. 1, Emission Test Results*. May 19, 1988. Prepared by Radian Corp. for EPA/OWRS.

APPENDIX A

PRETREATMENT CASE STUDY ANALYSIS: INDUSTRY MODEL PLANT CHARACTERISTICS

APPENDIX A

PRETREATMENT CASE STUDY ANALYSIS: INDUSTRY MODEL PLANT CHARACTERISTICS

- Inorganic Chemicals - The model plant chosen for this industry is a median production plant in the chlorine-diaphragm cell subcategory. This subcategory has the largest number of dischargers in the inorganic chemicals category. The SPS option is assumed to be a well-designed and operated lime, settle, and filter treatment system followed by dechlorination, and elimination of lead cell construction. PSES for this category is equalization, alkaline precipitation, and settling processes.

- Leather Tanning - The model plant for this category is a median production plant in the hair pulp/chrome tan/retan-wet finish subcategory, which is the subcategory with the highest number of dischargers. PSES for this category is catalytic oxidation of sulfides, flue gas carbonation, activated sludge with extended aeration, and powdered activated carbon addition. The SPS option is based on PSES plus well-designed and operated lime, settle, and filter treatment.

- Metal Finishing and Electroplating - The model plant for this category was chosen to represent plants that have a diverse waste stream and a median discharge flow rate. PSES for the category is chemical emulsion breaking, cyanide oxidation, chromium reduction, lime and settle, and sludge dewatering. The option considered as SPS is PSES plus 90 percent flow reduction through countercurrent rinsing, and a well-designed and operated lime and settle, cyanide precipitation and filtration system.

- Printing and Publishing - A film processing, non-metallic plate processing plant using press room water-based ink was chosen as the model facility. A well-designed and operated lime, settle, filtration, vacuum filtration system was assumed to be the SPS technology. Pretreatment standards have not been promulgated, but PSES was assumed to be lime, settle, and filtration, which is the most common technology.

- Pulp and Paper - A median production plant in the groundwood-fine papers subcategory was used as a model. The PSES technology of chemical substitution was assumed to achieve the highest reduction in metals for this category. No other, more stringent technology was identified for an SPS option.

- Metal Molding and Casting - Model plants in each of the aluminum, copper, zinc, and ferrous subcategories of metal molding and casting were examined. SPS is equal to PSES in each subcategory except for aluminum. In the aluminum subcategory, treatable levels of toxic metals remain after lime and settle systems. Therefore, SPS for the aluminum subcategory is based on PSES plus filtration. PSES for copper, zinc, and ferrous subcategories is recycle, lime and settle, and filtration. PSES for the aluminum subcategory is recycle, lime and settle.

- Iron and Steel - The model plant for this category is based on a facility of median production in the by-product coke-making subcategory. PSES is recycle, oil skimming, ammonia stripping, and pH adjustment. SPS is based on PSES plus cyanide precipitation with ferrous sulfate, followed by filtration.

- Organic Chemicals - The model plant was an organic chemicals plant that discharges 104,000,000 liters/yr. Pretreatment standards have not been promulgated for this category (as of 7/1/87). The PSES technology and associated improvements for SPS were assumed identical to those used at the model plant.

- Auto and Other Laundries - Two model plants were chosen for this category: (1) wand-type car wash with a flow of 128,000 liters/year; and (2) industrial laundry with the same flow as the car wash. There are no categorical pretreatment standards for this industry. The SPS technology was assumed to be dissolved air flotation plus filtration for both model plants.

- Battery Manufacturing - The model plant is a lead battery manufacturer discharging 2,700,000 liters/yr. The PSES technology is flow reduction, oil skimming, lime precipitation, and settling. The SPS option includes PSES plus polishing filtration.

- Electrical and Electronic Components - The model plant discharges 42,500,000 liters/yr and produces semiconductors, electronic crystals, color televisions, and t.v. phosphors. PSES for this category is solvent management, in-process chemical treatment for lead and chromium reduction, end-of-pipe neutralization, chemical precipitation/clarification, and sludge dewatering. The SPS option is PSES plus multimedia filtration.

- Plastics Molding and Forming - The model plant basis is a plant that processes 2,480 KKG/year of plastic and discharges 7,270,000 liters/year from the contact cooling and heating water subcategory and 4,540,000 liters/year from the cleaning water subcategory. The PSES option is to comply with the General Pretreatment Regulations, which do not regulate individual metals or organic chemicals. The SPS option includes equalization, pH adjustment, package activated sludge plant for the cleaning water subcategory and activated carbon for the contact cooling and heating water subcategory.

- Textiles - The model plant is a woven fabric finishing (desizing) plant discharging 2.1 billion liters/yr. The SPS technology is assumed to be biological treatment. No PSES has been promulgated.

- Non-Ferrous Metals Manufacturing - The model plant is in the precious metals subcategory and discharges 4,800,000 liters/yr of treated water. The PSES option for this subcategory is lime, settle, and filter with ammonia steam stripping, cyanide precipitation, flow reduction, and ion exchange end-of-pipe treatment. No more stringent technology was identified for an SPS option.

APPENDIX B

DETAILED CALCULATIONS FOR EACH CASE STUDY POTW

City of Goshen
Goshen, Indiana

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Electroplating and Metal Finishing

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year)								
			CD	CR	CU	PB	HG	NI	AG	ZN	CN
Artco	0.007	1	0.48	992.00	22.26	61.94	0.00	140.33	0.00	164.53	0.00
Midland	0.08	1	5.53	807.42	14.38	22.12	0.00	44.24	0.00	3373.48	0.00
Johnson	0.136	1	1052.97	902.55	20.68	75.21	0.00	56.41	0.00	3440.95	0.00

Company	Potential Improvement (kg/year reduction)								
	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Artco	0.47	982.08	21.59	59.46	0.00	137.52	0.00	159.59	0.00
Midland	5.36	799.35	13.95	21.24	0.00	43.36	0.00	3272.28	0.00
Johnson	1021.38	893.52	20.06	72.20	0.00	55.28	0.00	3337.73	0.00
Total Poll Removed(kg/year)	1027.21	2674.95	55.60	152.90	0.00	236.16	0.00	6769.60	0.00

Paint and Ink Formulating

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year)									
			CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l):			0.524	3.12	2.476	6.3	5.161	1.35	0.015	74.746	0.079	0.418
Anderson	0.0006	1	0.43	2.59	2.05	5.23	4.28	1.12	0.01	62.01	0.07	0.35
IvyTerrac	0.003	1	2.17	12.94	10.27	26.13	21.41	5.60	0.06	310.03	0.33	1.73

Company	Potential Improvement (kg/year reduction)									
	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Anderson	0.43	2.59	2.05	5.23	4.28	1.12	0.01	62.01	0.07	0.35
IvyTerrace	2.17	12.94	10.27	26.13	21.41	5.60	0.06	310.03	0.33	1.73
Total Poll Removed(kg/year)	2.61	15.53	12.32	31.36	25.69	6.72	0.07	372.03	0.39	2.08

Grand Total	Avg flow (MGD)	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Pollutant Removed		1029.82	2690.48	67.93	184.26	25.69	242.88	0.07	7141.63	0.39	2.08
Ave Effluent Loadings		0.11	0.6	0.38	0.1	0	0.49	0	3.34	0.1	
Total Plant Loadings (Kg/year)	3.24	1061.591	2717.496	1702.227	447.9545	0	2194.977	0	14961.68	447.9545	0
Percent Removed		97.0	99.0	4.0	41.1	0.0	11.1	0.0	47.7	0.1	0.0

GREEN BAY METRO SEWERAGE DISTRICT
GREEN BAY, WI

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

GREEN BAY METRO SEWERAGE DISTRICT
GREEN BAY, WI

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

RAW DATA

							MG/L				
Company	SIC	GALLONS PER DAY	CD	CR	CU	PB	HG	NI	AG	ZN	CN
					(data for indinvidual contributers on Mg/l supplied)						
Val plat	3471	400	0.05	0.011	0.008	0.018	0.0002	0.03	0.001	0.48	0.02
Val Engrav	3471	622	0.05	0.72	0.38	0.5	0.0002	1.04	0.13	3910	3.12
Astro Elec	3471	350	0.007	423	2.3	0.89	0.0002	0.06	0.05	0.47	0.02
Krueger	3471	258500	0.002	0.23	0.02	0.17	0.0004	0.91	0.005	0.006	0.03
Norelkote	3471	68900	0.01	0.05	0.16	0.07	0.0002	0.07	0.02	0.074	
N. Engrav	3471	660	0.004	0.08	1.79	0.14	0.012	0.12	0.07	0.58	0.15
NW Metal	3471	2500	0.01	0.04	0.03	0.08	0.0002	0.04	0.02	0.037	
Ultra Plat	3471	6500	0.39	11	0.41	0.86	0.0004	0.33	0.005	0.427	0.18
Gr By Mill	26	7659	0.02	0.11	7.54	1	0.002	0.8		0.38	0.32
Ft. Howard	332	7900	0.001	0.049	0.07	0.012	0.0002	0.31	0.04	0.26	0.02
PDQ Car	7542	15075	0.012	0.06	0.16	0.07	0.0002	0.1	0.001	1.19	0.02
Univ Laund	721	12525	0.001	0.017	0.13	0.01	0.003	0.009	0.002	0.43	0.02
G & K	721	43758	0	0.35	2.36	3.38	0.0051	0.16		7.41	0.02
Bay Towel	721	89648	0.001	0.12	0.43	0.18	0.0005	0.13		0.88	0.02
Medalcraft	nonfer	1500	1.93	0.17	86.5	0.26	0.0002	1.8	0.29	12.7	0.15
TOTAL PLANT:											
J. River			0.02	0.08	0.055	0.11	0.0005	0.1	0.02	0.055	
P&g			0.02	0.08	0.05	0.1	0.0005	0.08	0.02	0.076	
Rest			0.02	0.082	0.273	0.1	0.0005	0.113	0.02	0.309	

GREEN BAY METRO SEWERAGE DISTRICT
GREEN BAY, WI

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Electroplating and Metal Finishing

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year)								
			CD	CR	CU	PB	HG	NI	AG	ZN	CN
Val plat	0.0004	1	0.03	0.01	0.00	0.01	0.00	0.02	0.00	0.27	0.01
Val Engrav	0.0006	1	0.04	0.60	0.32	0.41	0.00	0.86	0.11	3243.52	2.59
Astro Elec	0.0004	1	0.00	233.93	1.27	0.49	0.00	0.03	0.03	0.26	0.01
Krueger	0.2585	1	0.71	82.20	7.15	60.76	0.14	325.23	1.79	2.14	10.72
Norelkote	0.0689	1	0.95	4.76	15.24	6.67	0.02	6.67	1.91	7.05	0.00
N. Engrav	0.0007	1	0.00	0.08	1.73	0.14	0.01	0.12	0.07	0.56	0.15
NW Metal	0.0025	1	0.03	0.14	0.10	0.28	0.00	0.14	0.07	0.13	0.00
Ultra Plat	0.0065	1	3.50	98.85	3.68	7.73	0.00	2.97	0.04	3.84	1.62

Company	Potential Improvement (kg/year reduction)								
	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Val plat	0.03	0.01	0.00	0.01	0.00	0.02	0.00	0.26	0.00
Val Engrav	0.04	0.59	0.31	0.40	0.00	0.85	0.10	3146.22	0.00
Astro Elec	0.00	231.59	1.23	0.47	0.00	0.03	0.03	0.25	0.00
Krueger	0.69	81.38	6.93	58.33	0.00	318.73	1.70	2.08	0.00
Norelkote	0.92	4.72	14.78	6.40	0.00	6.53	1.81	6.84	0.00
N. Engrav & Mach	0.00	0.08	1.68	0.13	0.00	0.11	0.06	0.54	0.00
NW Metal	0.03	0.14	0.10	0.27	0.00	0.14	0.07	0.12	0.00
Ultra Plat	3.40	97.87	3.57	7.42	0.00	2.91	0.04	3.72	0.00
Total Poll Removed(kg/yr)	5.13	416.36	28.62	73.42	0.00	329.31	3.81	3160.04	0.00

Pulp and Paper

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year)								
			CD	CR	CU	PB	HG	NI	AG	ZN	CN
Gr By Mill	0.0077	1	0.21	1.17	80.27	10.65	0.02	8.52	0.00	4.05	3.41
J. River	4	1	110.61	442.42	304.17	608.33	2.77	553.03	110.61	304.17	
P&g	14	1	387.12	1548.48	967.80	1935.61	9.68	1548.48	387.12	1471.06	

Company	Potential Improvement (kg/year reduction)								
	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Gr By Mill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
J. River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P&g	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	0	0

GREEN BAY METRO SEWERAGE DISTRICT
GREEN BAY, WI

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Iron & Steel

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Ft. Howard	0.0079	1	0.01	0.54	0.76	0.13	0.00	3.39	0.44	2.84	0.22

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Ft. Howard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	0	0.22

Car Wash

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
PDQ Car	0.0151	1	0.25	1.25	3.34	1.46	0.00	2.09	0.02	24.84	0.42

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
PDQ Car Wash	0.00	0.36	0.94	1.40	0.00	0.00	0.00	21.12	0.00
Total Poll Removed(kg/year)	0	0.36	0.94	1.4	0	0	0	21.12	0

Industrial Laundry

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Univ Laund	0.0125	1	0.02	0.29	2.25	0.17	0.05	0.16	0.03	7.43	0.35
G & K	0.0438	1	0.00	21.19	142.91	204.68	0.31	9.69	0.00	448.73	1.21
Bay Towel	0.0896	1	0.12	14.87	53.27	22.30	0.06	16.10	0.00	109.01	2.48

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
University Laundry	0.00	0.26	1.73	0.17	0.00	0.00	0.00	6.91	0.00
G & K	0.00	18.44	110.04	200.59	0.00	0.00	0.00	417.32	0.00
Bay Towel	0.02	12.93	41.02	21.85	0.00	0.00	0.00	101.38	0.00
Total Poll Removed(kg/year)	0.02	31.63	152.79	222.61	0	0	0	525.61	0

GREEN BAY METRO SEWERAGE DISTRICT
GREEN BAY, WI

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Nonferrous Metals Mfg.

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN
Medalcraft	0.0015	1	4.00	0.35	179.39	0.54	0.00	3.73	0.60	26.34	0.31

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN
Medalcraft Mint	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	0	0

Total Plant Flow

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN
J. River	4	1	110.61	442.42	304.17	608.33	2.77	553.03	110.61	304.17	
P&g	14	1	387.12	1548.48	967.80	1935.61	9.68	1548.48	387.12	1471.06	
Rest	17	1	470.08	1927.31	6416.53	2350.38	11.75	2655.93	470.08	7262.67	
Total	35	1	967.80	3918.22	7688.50	4894.32	24.20	4757.44	967.80	9037.90	

Grand Total		CD	CR	CU	PB	HG	NI	AG	ZN	CN
Pollutant Removed		5.15	448.35	182.35	297.43	0.00	329.31	3.81	3706.77	0.22
Plant Flow	35	967.8	3918.22	7688.5	4894.32	24.2	4757.44	967.8	9037.9	0
Percent Removed		0.5	11.4	2.4	6.1	0.0	6.9	0.4	41.0	0.0

Muscatine STP
Muscatine, Iowa

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Electroplating and Metal Finishing

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
(mg/l):			0.01	2.9	0.15	0.01	0.001	12.5	0	0.27	8.3
Hongen	0.079	1	1.09	316.75	16.38	1.09	0.11	1365.29	0.00	29.49	906.55

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Hongen	1.06	313.58	15.89	1.05	0.00	1337.99	0.00	28.61	0.00

Leather Tanning

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
(mg/l):			0.01	34	0.16	0.2	0.0002	0.17	0	0.22	0
Armira	0.347	1	4.80	16311.63	76.76	95.95	0.10	81.56	0.00	105.55	0.00

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Armira	0.00	15985.40	0.00	84.44	0.00	0.00	0.00	0.00	0.00

Grand Total	Avg flow (MGD)	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Pollutant Removed		1.06	16298.98	15.89	85.49	0.00	1337.99	0.00	28.61	0.00	0.00
Ave Influent(mg/l)		0.01	1.03	0.12	0.033	0.00153	0.827	0	0.45	0.0316	0
Plant Poll Loading	8.96	123.88	16628.38	1486.55	408.80	18.95	10244.78	0.00	5574.55	391.46	0.00
Percent Removed		0.9	98.0	1.1	20.9	0.0	13.1	0.0	0.5	0.0	0.0

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Inorganic Chemicals

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN
mg/l:			0.037	1.9	17	21	0.003	22	0.018	3	
Fid	0.001	1	0.05	2.63	23.50	29.03	0.00	30.42	0.02	4.15	
Heubach	0.387		19.80	1016.61	9095.97	11236.19	1.61	11771.25	9.63	1605.17	
Gen	0.109		5.58	286.33	2561.91	3164.72	0.45	3315.42	2.71	452.10	
Essex	0.086	1	4.40	225.91	2021.33	2496.93	0.36	2615.83	2.14	356.70	

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN
Fid	0.00	2.52	7.05	24.97	0.00	12.78	0.01	2.82	
Heubach	0.00	1006.44	8823.09	11123.83	0.00	11535.83	2.70	1380.45	
Gen	0.00	283.47	2485.06	3133.07	0.00	3249.11	0.76	388.81	
Essex	0.00	216.88	606.40	2147.36	0.00	1098.65	0.60	242.56	
Total Poll Removed(kg/year)	0	1509.308	11921.59	16429.23	0	15896.35	4.06245	2014.634	

Electroplating and Metal Finishing

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN
mg/l:			0.283	27.46	12.63	0.331	0.001	15.47	0.023	12.47	1.856
Acme	0.0096	1	3.76	364.47	167.63	4.39	0.01	205.33	0.31	165.51	24.63
Aircraft	0.006	1	2.35	227.79	104.77	2.75	0.01	128.33	0.19	103.44	15.40
Alcaro	0.023		9.00	873.21	401.62	10.53	0.03	491.93	0.73	396.54	59.02
Alfred	0.003		1.17	113.90	52.39	1.37	0.00	64.17	0.10	51.72	7.70
AmerBump	0.008	1	3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
AmerElec	0.008	1	3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
Andarn	0.0084	1	3.29	318.91	146.68	3.84	0.01	179.66	0.27	144.82	21.55
Anodiz	0.009	1	3.52	341.69	157.16	4.12	0.01	192.50	0.29	155.17	23.09
Aurilyte	0.009	1	3.52	341.69	157.16	4.12	0.01	192.50	0.29	155.17	23.09
AutoElec	0.047		18.39	1784.38	820.71	21.51	0.06	1005.26	1.49	810.31	120.60
Beamar	0.001	1	0.39	37.97	17.46	0.46	0.00	21.39	0.03	17.24	2.57
Best	0.008	1	3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
CPatti	0.01	1	3.91	379.66	174.62	4.58	0.01	213.88	0.32	172.41	25.66
ChromeArt	0.0069		2.70	261.96	120.49	3.16	0.01	147.58	0.22	118.96	17.71
CircuitMa	0.004	1	1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
Comet	0.0005	1	0.20	18.98	8.73	0.23	0.00	10.69	0.02	8.62	1.28
Diamond	0.0005	1	0.20	18.98	8.73	0.23	0.00	10.69	0.02	8.62	1.28
Double	0.011	1	4.30	417.62	192.08	5.03	0.02	235.27	0.35	189.65	28.23
Durite	0.004	1	1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing (Cont.)

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN
ECElec	0.015	1	5.87	569.48	261.93	6.86	0.02	320.83	0.48	258.61	38.49
ElCircuit	0.004		1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
ElProc	0.007	1	2.74	265.76	122.23	3.20	0.01	149.72	0.22	120.69	17.96
GH Metal	0.009	1	3.52	341.69	157.16	4.12	0.01	192.50	0.29	155.17	23.09
GenMet	0.0477	1	18.66	1810.96	832.93	21.83	0.07	1020.23	1.52	822.38	122.40
Highland	0.004	1	1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
HyGrade	0.0016	1	0.63	60.74	27.94	0.73	0.00	34.22	0.05	27.59	4.11
Ideal	0.024		9.39	911.17	419.09	10.98	0.03	513.32	0.76	413.78	61.59
Imperial	0.026		10.17	987.10	454.01	11.90	0.04	556.10	0.83	448.26	66.72
IndPlat	0.069		27.00	2619.62	1204.87	31.58	0.10	1475.80	2.19	1189.61	177.06
IndHard	0.002	1	0.78	75.93	34.92	0.92	0.00	42.78	0.06	34.48	5.13
JCMet	0.007	1	2.74	265.76	122.23	3.20	0.01	149.72	0.22	120.69	17.96
Keystone	0.008	1	3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
Kohinoor	0.019	1	7.43	721.35	331.78	8.70	0.03	406.38	0.60	327.57	48.76
Loisel	0.01	1	3.91	379.66	174.62	4.58	0.01	213.88	0.32	172.41	25.66
Manco	0.0005	1	0.20	18.98	8.73	0.23	0.00	10.69	0.02	8.62	1.28
Mara	0.0018	1	0.70	68.34	31.43	0.82	0.00	38.50	0.06	31.03	4.62
Miller	0.038		14.87	1442.69	663.55	17.39	0.05	812.76	1.21	655.15	97.51
Mottern	0.003	1	1.17	113.90	52.39	1.37	0.00	64.17	0.10	51.72	7.70
Moyer	0.008		3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
NJ Gal	0.011		4.30	417.62	192.08	5.03	0.02	235.27	0.35	189.65	28.23
NuTron	0.013		5.09	493.55	227.01	5.95	0.02	278.05	0.41	224.13	33.36
Ondecker	0.0035	1	1.37	132.88	61.12	1.60	0.00	74.86	0.11	60.34	8.98
PNC	0.017		6.65	645.41	296.85	7.78	0.02	363.60	0.54	293.09	43.62
PanGraph	0.015	1	5.87	569.48	261.93	6.86	0.02	320.83	0.48	258.61	38.49
Para	0.0095	1	3.72	360.67	165.89	4.35	0.01	203.19	0.30	163.79	24.38
PlatCity	0.0065	1	2.54	246.78	113.50	2.97	0.01	139.02	0.21	112.06	16.68
Polaris	0.012	1	4.70	455.59	209.54	5.49	0.02	256.66	0.38	206.89	30.79
Precision	0.005	1	1.96	189.83	87.31	2.29	0.01	106.94	0.16	86.20	12.83
PrecProt	0.004	1	1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
QualMet	0.002	1	0.78	75.93	34.92	0.92	0.00	42.78	0.06	34.48	5.13
Ranno	0.047		18.39	1784.38	820.71	21.51	0.06	1005.26	1.49	810.31	120.60
Redi	0.0069	1	2.70	261.96	120.49	3.16	0.01	147.58	0.22	118.96	17.71
Rennie	0.004	1	1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
Reyom	0.0029	1	1.13	110.10	50.64	1.33	0.00	62.03	0.09	50.00	7.44
Suffern	0.053		20.74	2012.17	925.48	24.25	0.07	1133.59	1.69	913.76	136.00
SurMet	0.031		12.13	1176.93	541.32	14.19	0.04	663.04	0.99	534.46	79.55
TAFar	0.009	1	3.52	341.69	157.16	4.12	0.01	192.50	0.29	155.17	23.09
Timco	0.005	1	1.96	189.83	87.31	2.29	0.01	106.94	0.16	86.20	12.83
Trb/alb	0.001	1	0.39	37.97	17.46	0.46	0.00	21.39	0.03	17.24	2.57
Trio	0.0023	1	0.90	87.32	40.16	1.05	0.00	49.19	0.07	39.65	5.90
Arrow	0.133		52.04	5049.42	2322.44	60.87	0.18	2844.66	4.23	2293.02	341.29
ArtMet	0.029		11.35	1101.00	506.40	13.27	0.04	620.26	0.92	499.98	74.42
CALaus	0.001	1	0.39	37.97	17.46	0.46	0.00	21.39	0.03	17.24	2.57
Conrad	0.029		11.35	1101.00	506.40	13.27	0.04	620.26	0.92	499.98	74.42

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing (Cont.)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
			Typical Raw Wastes (Kg/year)								
Daytona	0.012		4.70	455.59	209.54	5.49	0.02	256.66	0.38	206.89	30.79
Edmar	0.032		12.52	1214.90	558.78	14.64	0.04	684.43	1.02	551.70	82.11
Gloube	0.004		1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
Gordos	0.008	1	3.13	303.72	139.70	3.66	0.01	171.11	0.25	137.93	20.53
ITT	0.176	1	68.86	6681.93	3073.30	80.54	0.24	3764.37	5.60	3034.37	451.63
JBHirsh	0.001	1	0.39	37.97	17.46	0.46	0.00	21.39	0.03	17.24	2.57
Medin	0.0009	1	0.35	34.17	15.72	0.41	0.00	19.25	0.03	15.52	2.31
Presto	0.257		100.56	9757.14	4487.72	117.61	0.36	5496.83	8.17	4430.86	659.48
Philips	0.004		1.57	151.86	69.85	1.83	0.01	85.55	0.13	68.96	10.26
TEInd	0.012	1	4.70	455.59	209.54	5.49	0.02	256.66	0.38	206.89	30.79
Wallace&T	0.105		41.08	3986.38	1833.50	48.05	0.15	2245.79	3.34	1810.28	269.44
Weston	0.018	1	7.04	683.38	314.31	8.24	0.02	384.99	0.57	310.33	46.19
Westwood	0.063	1	24.65	2391.83	1100.10	28.83	0.09	1347.47	2.00	1086.17	161.66
Vibra	0.006		2.35	227.79	104.77	2.75	0.01	128.33	0.19	103.44	15.40

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Acme	3.64	360.82	162.61	4.22	0.00	201.22	0.29	160.55	0.00
Aircraft	2.28	225.52	101.63	2.64	0.00	125.76	0.18	100.34	0.00
Alcaro	8.73	873.21	401.62	10.10	0.00	491.93	0.69	396.54	38.36
Alfred	1.14	113.90	52.39	1.32	0.00	64.17	0.09	51.72	5.00
AmerBump	3.04	300.69	135.50	3.51	0.00	167.69	0.24	133.79	0.00
AmerElec	3.04	300.69	135.50	3.51	0.00	167.69	0.24	133.79	0.00
Andarn	3.19	315.72	142.28	3.69	0.00	176.07	0.25	140.48	0.00
Anodiz	3.42	338.27	152.44	3.95	0.00	188.65	0.27	150.51	0.00
Aurilyte	3.42	338.27	152.44	3.95	0.00	188.65	0.27	150.51	0.00
AutoElec	17.84	1784.38	820.71	20.65	0.00	1005.26	1.42	810.31	78.39
Beamar	0.38	37.59	16.94	0.44	0.00	20.96	0.03	16.72	0.00
Best	3.04	300.69	135.50	3.51	0.00	167.69	0.24	133.79	0.00
CPatti	3.80	375.86	169.38	4.39	0.00	209.61	0.30	167.23	0.00
ChromeArt	2.62	261.96	120.49	3.03	0.00	147.58	0.21	118.96	11.51
CircuitMan	1.52	150.34	67.75	1.76	0.00	83.84	0.12	66.89	0.00
Comet	0.19	18.79	8.47	0.22	0.00	10.48	0.02	8.36	0.00
Diamond	0.19	18.79	8.47	0.22	0.00	10.48	0.02	8.36	0.00
Double	4.17	413.44	186.32	4.83	0.00	230.57	0.33	183.96	0.00
Durite	1.52	150.34	67.75	1.76	0.00	83.84	0.12	66.89	0.00
ECElec	5.69	563.79	254.07	6.59	0.00	314.41	0.45	250.85	0.00
ElCircuit	1.52	151.86	69.85	1.76	0.00	85.55	0.12	68.96	6.67
ElProc	2.66	263.10	118.57	3.08	0.00	146.72	0.21	117.06	0.00
GM Metal	3.42	338.27	152.44	3.95	0.00	188.65	0.27	150.51	0.00
GenMet	18.10	1792.85	807.95	20.96	0.00	999.82	1.44	797.71	0.00
Highland	1.52	150.34	67.75	1.76	0.00	83.84	0.12	66.89	0.00
HyGrade	0.61	60.14	27.10	0.70	0.00	33.54	0.05	26.76	0.00

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing (Cont.)

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN
Ideal	9.11	911.17	419.09	10.54	0.00	513.32	0.73	413.78	40.03
Imperial	9.87	987.10	454.01	11.42	0.00	556.10	0.79	448.26	43.37
IndPlat	26.19	2619.62	1204.87	30.31	0.00	1475.80	2.08	1189.61	115.09
IndHard	0.76	75.17	33.88	0.88	0.00	41.92	0.06	33.45	0.00
JCMet	2.66	263.10	118.57	3.08	0.00	146.72	0.21	117.06	0.00
Keystone	3.04	300.69	135.50	3.51	0.00	167.69	0.24	133.79	0.00
Kohinoor	7.21	714.13	321.82	8.35	0.00	398.25	0.57	317.75	0.00
Loisel	3.80	375.86	169.38	4.39	0.00	209.61	0.30	167.23	0.00
Manco	0.19	18.79	8.47	0.22	0.00	10.48	0.02	8.36	0.00
Mara	0.68	67.65	30.49	0.79	0.00	37.73	0.05	30.10	0.00
Miller	14.42	1442.69	663.55	16.69	0.00	812.76	1.15	655.15	63.38
Mottern	1.14	112.76	50.81	1.32	0.00	62.88	0.09	50.17	0.00
Moyer	3.04	303.72	139.70	3.51	0.00	171.11	0.24	137.93	13.34
NJ Gal	4.17	417.62	192.08	4.83	0.00	235.27	0.33	189.65	18.35
NuTron	4.93	493.55	227.01	5.71	0.00	278.05	0.39	224.13	21.68
Ondecker	1.33	131.55	59.28	1.54	0.00	73.36	0.11	58.53	0.00
PNC	6.45	645.41	296.85	7.47	0.00	363.60	0.51	293.09	28.35
PenGraph	5.69	563.79	254.07	6.59	0.00	314.41	0.45	250.85	0.00
Para	3.61	357.07	160.91	4.17	0.00	199.13	0.29	158.87	0.00
PlatCity	2.47	244.31	110.10	2.86	0.00	136.24	0.20	108.70	0.00
Polaris	4.55	451.03	203.26	5.27	0.00	251.53	0.36	200.68	0.00
Precision	1.90	187.93	84.69	2.20	0.00	104.80	0.15	83.62	0.00
PrecProt	1.52	150.34	67.75	1.76	0.00	83.84	0.12	66.89	0.00
QualMet	0.76	75.17	33.88	0.88	0.00	41.92	0.06	33.45	0.00
Ranno	17.84	1784.38	820.71	20.65	0.00	1005.26	1.42	810.31	78.39
Redi	2.62	259.34	116.87	3.03	0.00	144.63	0.21	115.39	0.00
Rennie	1.52	150.34	67.75	1.76	0.00	83.84	0.12	66.89	0.00
Reyom	1.10	109.00	49.12	1.27	0.00	60.79	0.09	48.50	0.00
Suffern	20.12	2012.17	925.48	23.28	0.00	1133.59	1.60	913.76	88.40
SunMet	11.77	1176.93	541.32	13.62	0.00	663.04	0.94	534.46	51.71
TAFar	3.42	338.27	152.44	3.95	0.00	188.65	0.27	150.51	0.00
Timco	1.90	187.93	84.69	2.20	0.00	104.80	0.15	83.62	0.00
Trb/alb	0.38	37.59	16.94	0.44	0.00	20.96	0.03	16.72	0.00
Trio	0.87	86.45	38.96	1.01	0.00	48.21	0.07	38.46	0.00
Arrow	50.48	5049.42	2322.44	58.43	0.00	2844.66	4.02	2293.02	221.84
ArtMet	11.01	1101.00	506.40	12.74	0.00	620.26	0.88	499.98	48.37
CALaum	0.38	37.59	16.94	0.44	0.00	20.96	0.03	16.72	0.00
Conrad	11.01	1101.00	506.40	12.74	0.00	620.26	0.88	499.98	48.37
Daytona	4.55	455.59	209.54	5.27	0.00	256.66	0.36	206.89	20.02
Edmar	12.16	1214.90	558.78	14.06	0.00	684.43	0.97	551.70	53.37
Gloube	1.52	151.86	69.85	1.76	0.00	85.55	0.12	68.96	6.67
Gordos	3.04	300.69	135.50	3.51	0.00	167.69	0.24	133.79	0.00
ITT	66.80	6615.11	2981.10	77.32	0.00	3689.08	5.32	2943.34	0.00
JBHirsh	0.38	37.59	16.94	0.44	0.00	20.96	0.03	16.72	0.00
Medin	0.34	33.83	15.24	0.40	0.00	18.86	0.03	15.05	0.00

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing (Cont.)

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Presto	97.54	9757.14	4487.72	112.91	0.00	5496.83	7.76	4430.86	428.66
Philips	1.52	151.86	69.85	1.76	0.00	85.55	0.12	68.96	6.67
TEInd	4.55	451.03	203.26	5.27	0.00	251.53	0.36	200.68	0.00
Wallace&T	39.85	3986.38	1833.50	46.13	0.00	2245.79	3.17	1810.28	175.13
Weston	6.83	676.55	304.89	7.91	0.00	377.29	0.54	301.02	0.00
Westwood	23.91	2367.91	1067.10	27.68	0.00	1320.52	1.90	1053.58	0.00
Vibra	2.28	227.79	104.77	2.64	0.00	128.33	0.18	103.44	10.01

Electroplating and Metal Finishing									
Total Poll Removed(kg/year)	619.77	61769.50	28200.44	717.42	0.00	34670.20	49.33	27843.19	1721.15

Iron and Steel Manufacturing

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
mg/l:			0	0	0	0	0	0	0	0.2	50
NatStand	0.141		0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.99	9747.16

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
NatStand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9747.16

Leather Tanning

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
mg/l:			0	160	0.05	1.1	0	0.06	0	0.05	0
NJ Tan	0.027	1	0.00	5972.73	1.87	41.06	0.00	2.24	0.00	1.87	0.00
Ocean	0.346		0.00	76539.39	23.92	526.21	0.00	28.70	0.00	23.92	0.00
Seton	1.153		0.00	255058	79.71	1753.52	0.00	95.65	0.00	79.71	0.00

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
NJ Tan	0.00	5853.27	0.00	36.14	0.00	0.00	0.00	0.00	0.00
Ocean	0.00	76539.39	0.00	463.06	0.00	0.00	0.00	0.00	0.00
Seton	0.00	255058	0.00	1543.10	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0	337450.2	0	2042.296	0	0	0	0	0

Pulp and Paper

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
mg/l:			0	0.005	0.028	0.009	0	0.005	0	0.074	0	0.007
Chin Am	0.567	1	0.00	3.92	21.95	7.06	0.00	3.92	0.00	58.01	0.00	5.49
GardenSt	7.269	1	0.00	50.25	281.40	90.45	0.00	50.25	0.00	743.70	0.00	70.35
Marcal	3.073	1	0.00	21.24	118.96	38.24	0.00	21.24	0.00	314.40	0.00	29.74
Newark	0.138	1	0.00	0.95	5.34	1.72	0.00	0.95	0.00	14.12	0.00	1.34

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Ch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gardens.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marcal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Newark	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	0	0	0

Aluminum Forming

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
mg/l:			0	0	0.132	0.237	0	0.028	0	1.897	0	8.014
Warner	0.001	1	0.00	0.00	0.18	0.33	0.00	0.04	0.00	2.62	0.00	11.08

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Warner	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.84	0.00	0.00

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Copper Forming

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
mg/l:			0.009	0	0.911	0.235	0	0.007	0	1.27	0	0.007
LittleFal	0.014		0.17	0.00	17.63	4.55	0.00	0.14	0.00	24.58	0.00	0.14
Okonite	0.029	1	0.36	0.00	36.53	9.42	0.00	0.28	0.00	50.92	0.00	0.28

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
LittleFal	0.17	0.00	17.63	4.50	0.00	0.13	0.00	24.58	0.00	0.13
Okonite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0.17	0.00	17.63	4.50	0.00	0.13	0.00	24.58	0.00	0.13

Plastics Molding & Forming

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
mg/l:			0	0	0	0	0	0	0	0.598	0	0.098
VanNess	0.071	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.70	0.00	9.62
KleerKast	0.033	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.28	0.00	4.47
Hartz	0.051	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.17	0.00	6.91
Wallace	0.105	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.81	0.00	14.23

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
VanNess	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.39	0.00	8.66
KleerKast	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.92	0.00	4.02
Hartz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.14	0.00	6.22
Wallace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.82	0.00	12.80
Total Poll Removed(kg/year)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	133.28	0.00	31.71

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Battery Manufacturing

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
			Typical Raw Wastes (Kg/year)									
mg/l:			0.0005	0.07	0.176	206	0.008	0.073	0.0188	0.487	0	0
PowerBat	0.001	1	0.00	0.11	0.24	284.81	0.01	0.10	0.03	0.67	0.00	0.00

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
	Potential Improvement (kg/year reduction)									
PowerBat	0.00	0.02	0.14	0.00	0.00	0.07	0.00	0.22	0.00	0.00

Non-Ferrous Metals

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
			Typical Raw Wastes (Kg/year)									
mg/l:			0.319	2.87	1.68	0.07	0	32.8	0	0.18	0	0
Certified	0.011	0	4.85	43.65	25.55	1.06	0.00	498.83	0.00	2.74	0.00	0.00
Engelhard	0.038	0	16.76	150.78	88.26	3.68	0.00	1723.24	0.00	9.46	0.00	0.00
OMI	0.06	0	26.46	238.08	139.36	5.81	0.00	2720.91	0.00	14.93	0.00	0.00

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
	Potential Improvement (kg/year reduction)									
Certified	4.75	43.65	25.04	0.95	0.00	498.83	0.00	2.41	0.00	0.00
Engelhard	16.42	150.78	86.50	3.27	0.00	1723.24	0.00	8.32	0.00	0.00
OMI	25.93	238.08	136.58	5.17	0.00	2720.91	0.00	13.14	0.00	0.00
Total Poll Removed(kg/year)	47.11	432.51	248.11	9.39	0.00	4942.98	0.00	23.87	0.00	0.00

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Textile Mills

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
			Typical Raw Wastes (Kg/year)									
mg/l:			0	0.787	0.656	0	0	0	0	0.999	0.071	0.21
ALDyers	0.011	1	0.00	11.97	9.98	0.00	0.00	0.00	0.00	15.19	1.08	3.19
Apollo	0.017	1	0.00	18.50	15.42	0.00	0.00	0.00	0.00	23.48	1.67	4.94
Baltic	0.07	1	0.00	76.17	63.49	0.00	0.00	0.00	0.00	96.68	6.87	20.32
Boris	0.104	1	0.00	113.16	94.32	0.00	0.00	0.00	0.00	143.64	10.21	30.20
Champion	0.067	1	0.00	72.90	60.77	0.00	0.00	0.00	0.00	92.54	6.58	19.45
Columbia	0.559	1	0.00	608.24	507.00	0.00	0.00	0.00	0.00	772.09	54.87	162.30
Como	0.135	1	0.00	146.89	122.44	0.00	0.00	0.00	0.00	186.46	13.25	39.20
Coral	0.164	1	0.00	178.45	148.74	0.00	0.00	0.00	0.00	226.52	16.10	47.62
Craft	0.318	1	0.00	346.01	288.42	0.00	0.00	0.00	0.00	439.22	31.22	92.33
Dyetex	0.467	1	0.00	508.14	423.55	0.00	0.00	0.00	0.00	645.02	45.84	135.59
Empire	0.024	1	0.00	26.11	21.77	0.00	0.00	0.00	0.00	33.15	2.36	6.97
EWPiece	0.023	1	0.00	25.03	20.86	0.00	0.00	0.00	0.00	31.77	2.26	6.68
InterVeil	0.063	1	0.00	68.55	57.14	0.00	0.00	0.00	0.00	87.02	6.18	18.29
Interstat	0.045	1	0.00	48.96	40.81	0.00	0.00	0.00	0.00	62.15	4.42	13.07
Leader	0.381	1	0.00	414.56	345.56	0.00	0.00	0.00	0.00	526.23	37.40	110.62
Manner	0.094	1	0.00	102.28	85.26	0.00	0.00	0.00	0.00	129.83	9.23	27.29
Missbrenn	0.41	1	0.00	446.12	371.86	0.00	0.00	0.00	0.00	566.29	40.25	119.04
NJersey	0.033	1	0.00	35.91	29.93	0.00	0.00	0.00	0.00	45.58	3.24	9.58
Paragon	0.03	1	0.00	32.64	27.21	0.00	0.00	0.00	0.00	41.44	2.94	8.71
Paterson	0.043	1	0.00	46.79	39.00	0.00	0.00	0.00	0.00	59.39	4.22	12.48
Paul's	0.026	1	0.00	28.29	23.58	0.00	0.00	0.00	0.00	35.91	2.55	7.55
Perennial	0.096	1	0.00	104.46	87.07	0.00	0.00	0.00	0.00	132.59	9.42	27.87
Signature	0.135	1	0.00	146.89	122.44	0.00	0.00	0.00	0.00	186.46	13.25	39.20
Poughkeep	0.247	1	0.00	268.76	224.02	0.00	0.00	0.00	0.00	341.15	24.25	71.71
Rainbow	0.066	1	0.00	71.81	59.86	0.00	0.00	0.00	0.00	91.16	6.48	19.16
Renco	0.09	1	0.00	97.93	81.63	0.00	0.00	0.00	0.00	124.31	8.83	26.13
Stacy	0.047	1	0.00	51.14	42.63	0.00	0.00	0.00	0.00	64.92	4.61	13.65
Sunbrite	0.102	1	0.00	110.98	92.51	0.00	0.00	0.00	0.00	140.88	10.01	29.61
TextilePl	0.176	1	0.00	191.50	159.63	0.00	0.00	0.00	0.00	243.09	17.28	51.10
Thomas	0.008	1	0.00	8.70	7.26	0.00	0.00	0.00	0.00	11.05	0.79	2.32
Thorn	0.113	1	0.00	122.95	102.49	0.00	0.00	0.00	0.00	156.07	11.09	32.81
Trio	1.359	1	0.00	1478.71	1232.57	0.00	0.00	0.00	0.00	1877.04	133.40	394.57
Zenith	0.162	1	0.00	176.27	146.93	0.00	0.00	0.00	0.00	223.75	15.90	47.04

Passaic Valley Sewerage Commissioners
Newark, New Jersey

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
ALDyers	0.00	4.79	3.99	0.00	0.00	0.00	0.00	5.93	1.08	3.03
Apollo	0.00	7.40	6.17	0.00	0.00	0.00	0.00	9.16	1.67	4.69
Baltic	0.00	30.47	25.40	0.00	0.00	0.00	0.00	37.71	6.87	19.31
Boris	0.00	45.26	37.73	0.00	0.00	0.00	0.00	56.02	10.21	28.69
Champion	0.00	29.16	24.31	0.00	0.00	0.00	0.00	36.09	6.58	18.48
Columbia	0.00	243.30	202.80	0.00	0.00	0.00	0.00	301.11	54.87	154.19
Como	0.00	58.76	48.98	0.00	0.00	0.00	0.00	72.72	13.25	37.24
Coral	0.00	71.38	59.50	0.00	0.00	0.00	0.00	88.34	16.10	45.24
Craft	0.00	138.40	115.37	0.00	0.00	0.00	0.00	171.30	31.22	87.71
Dyetex	0.00	203.25	169.42	0.00	0.00	0.00	0.00	251.56	45.84	128.81
Empire	0.00	10.45	8.71	0.00	0.00	0.00	0.00	12.93	2.36	6.62
EWPiece	0.00	10.01	8.34	0.00	0.00	0.00	0.00	12.39	2.26	6.34
InterVeil	0.00	27.42	22.86	0.00	0.00	0.00	0.00	33.94	6.18	17.38
Interstate	0.00	19.59	16.33	0.00	0.00	0.00	0.00	24.24	4.42	12.41
Leader	0.00	165.82	138.22	0.00	0.00	0.00	0.00	205.23	37.40	105.09
Manner	0.00	40.91	34.10	0.00	0.00	0.00	0.00	50.63	9.23	25.93
Nissbrenner	0.00	178.45	148.74	0.00	0.00	0.00	0.00	220.85	40.25	113.09
NJersey	0.00	14.36	11.97	0.00	0.00	0.00	0.00	17.78	3.24	9.10
Paragon	0.00	13.06	10.88	0.00	0.00	0.00	0.00	16.16	2.94	8.27
Paterson	0.00	18.72	15.60	0.00	0.00	0.00	0.00	23.16	4.22	11.86
Paul's	0.00	11.32	9.43	0.00	0.00	0.00	0.00	14.01	2.55	7.17
Perennial	0.00	41.78	34.83	0.00	0.00	0.00	0.00	51.71	9.42	26.48
Signature	0.00	58.76	48.98	0.00	0.00	0.00	0.00	72.72	13.25	37.24
Poughkeep	0.00	107.50	89.61	0.00	0.00	0.00	0.00	133.05	24.25	68.13
Rainbow	0.00	28.73	23.94	0.00	0.00	0.00	0.00	35.55	6.48	18.20
Renco	0.00	39.17	32.65	0.00	0.00	0.00	0.00	48.48	8.83	24.82
Stacy	0.00	20.46	17.05	0.00	0.00	0.00	0.00	25.32	4.61	12.96
Sunbrite	0.00	44.39	37.00	0.00	0.00	0.00	0.00	54.94	10.01	28.13
TextilePiece	0.00	76.60	63.85	0.00	0.00	0.00	0.00	94.81	17.28	48.55
Thomas	0.00	3.48	2.90	0.00	0.00	0.00	0.00	4.31	0.79	2.21
Thorn	0.00	49.18	41.00	0.00	0.00	0.00	0.00	60.87	11.09	31.17
Trio	0.00	591.48	493.03	0.00	0.00	0.00	0.00	732.05	133.40	374.84
Zenith	0.00	70.51	58.77	0.00	0.00	0.00	0.00	87.26	15.90	44.68
Total Poll Removed(kg/year)	0.00	2474.31	2062.45	0.00	0.00	0.00	0.00	3062.31	558.06	1568.06

Grand Total	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Pollutant Removed	667.1	89590.9	42450.4	19202.9	0.0	49938.6	53.4	33102.9	12026.4	1599.9
Total Plant Loading (Kg/year)	6636.4	89590.9	77147.7	121943.2	1327.3	49938.6		324684.1		
Percent Removed	10.1	100.0	55.0	15.7	0.0	100.0	0.0	10.2	0.0	0.0

River Road
Wichita Falls, TX

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
			Typical Raw Wastes (Kg/year)								
Stanley	0.048	1	1.26	139.36	24.55	3.32	0.00	491.09	0.00	19.91	0.00
Tranter	0.01	1	0.11	1.59	0.00	0.00	0.00	10.23	0.00	3.00	0.00
Hawmet	0.027	1	0.22	6.35	1.31	0.00	0.00	27.62	0.00	0.00	0.00
HawmetRef	0.004	1	0.00	0.00	0.25	0.00	0.00	6.69	0.00	2.77	0.00

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Stanley	1.22	137.97	23.82	3.19	0.00	481.27	0.00	19.31	0.00
Tranter	0.11	1.57	0.00	0.00	0.00	10.03	0.00	2.91	0.00
Hawmet	0.22	6.28	1.27	0.00	0.00	27.07	0.00	0.00	0.00
HawmetRef	0.00	0.00	0.24	0.00	0.00	6.56	0.00	2.68	0.00
Total Poll Removed(kg/year)	1.55	145.83	25.33	3.19	0.00	524.92	0.00	24.90	0.00

Battery Manufacturing

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
			Typical Raw Wastes (Kg/year)								
AC	0.04	1	0.00	0.00	3.43	6.19	0.00	3.87	0.00	0.00	0.00

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
AC	0.00	0.00	1.95	0.00	0.00	2.75	0.00	0.00	0.00

Grand Total	Avg flow (MGD)	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Pollutant Removed		1.55	145.83	27.28	3.19	0.00	527.67	0.00	24.90	0.00	0.00
Average Influent(mg/l)		0.01	0.22	0.13	0.09	0.01	0.01		0.33		
Total Plant Loadin (Kg/year)	11	152.08	3345.83	1977.08	1368.75	152.08	535.64	0.00	5018.75	0.00	0.00
Percent Removable		1.0	4.4	1.4	0.2	0.0	98.5	0.0	0.5	0.0	0.0

Trinity River Authority
Grand Prarie, TX

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575

Electroplating and Metal Finishing

	Avg flow	In	Typical Raw Wastes (Kg/year)								
Company	(MGD)	Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Gen Mag	0.0242	1	0.47	2.24	0.00	1.10	0.00	2.54	0.01	0.00	167.29
Groff	0.0146	1	0.00	0.10	0.46	0.00	0.00	0.20	0.00	2.42	1.01
LFC	0.0025	1	0.44	0.15	34.77	0.00	0.00	0.00	0.00	0.00	0.17
Electro	0.016	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irving	0.004		0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Western	0.008		0.00	191.35	0.00	0.00	0.00	0.00	0.00	0.77	0.00
Texas	0.004	1	0.00	3.32	0.00	0.00	0.00	0.00	0.00	0.55	0.00
EDM	0.02	1	0.00	12.44	0.00	0.00	0.00	165.91	0.00	13.83	0.00
Atlas	0.01		0.00	276.52	0.00	0.00	0.00	0.00	0.00	4.84	0.00
NatHand	0.093	1	0.00	280.30	6.43	1.29	0.00	119.58	0.00	9.00	0.00
BMC	0.044	1	47.45	220.22	141.74	13.38	0.00	338.84	0.00	193.45	114.37
RediStrip	0.0021	1	0.12	2.93	1.92	1.07	0.00	0.52	0.00	2.67	0.90
LTV	1.1525	1	63.74	5529.16	207.14	223.08	0.00	414.29	79.67	302.75	1035.72
NatMet	0.0209	1	38.72	143.03	17.92	8.09	0.00	95.07	1.44	15.89	19.65
HEB	0.0035		0.01	396.80	0.01	0.05	0.00	343.57	0.00	2.47	0.00
Edd's	0.02	1	52.54	24.33	161.76	1.38	0.00	65.53	0.00	45.63	77.98

	Potential Improvement (kg/year reduction)								
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Gen Mag	0.45	2.22	0.00	1.06	0.00	2.49	0.01	0.00	0.00
Groff	0.00	0.10	0.45	0.00	0.00	0.20	0.00	2.35	0.00
LFC	0.42	0.14	33.73	0.00	0.00	0.00	0.00	0.00	0.00
Electro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irving	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Western	0.00	191.35	0.00	0.00	0.00	0.00	0.00	0.77	0.00
Texas	0.00	3.29	0.00	0.00	0.00	0.00	0.00	0.54	0.00
EDM	0.00	12.32	0.00	0.00	0.00	162.59	0.00	13.41	0.00
Atlas	0.00	276.52	0.00	0.00	0.00	0.00	0.00	4.84	0.00
NatHand	0.00	277.50	6.24	1.23	0.00	117.19	0.00	8.73	0.00
BMC	46.03	218.01	137.49	12.85	0.00	332.06	0.00	187.65	0.00
RediStrip	0.11	2.90	1.86	1.03	0.00	0.51	0.00	2.59	0.00
LTV	61.82	5473.87	200.93	214.16	0.00	406.00	75.69	293.67	0.00
NatMet	37.56	141.60	17.38	7.77	0.00	93.17	1.37	15.42	0.00
HEB	0.01	396.80	0.01	0.05	0.00	343.57	0.00	2.47	0.00
Edd's	50.96	26.09	156.91	1.33	0.00	64.22	0.00	44.26	0.00
Total Poll Removed(kg/year)	197.37	7021.27	554.99	239.47	0.00	1522.01	77.07	576.69	0.00

Trinity River Authority
Grand Prarie, TX

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Inorganic Chemicals

			Typical Raw Wastes (Kg/year)								
Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Mohawk	0.08	1	0.00	5.53	16.59	5.53	0.00	0.00	1.11	0.00	

	Potential Improvement (kg/year reduction)								
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Mohawk	0.00	5.31	4.98	4.76	0.00	0.00	0.31	0.00	

Pulp and Paper

			Typical Raw Wastes (Kg/year)									
Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Western	0.053	1	0.00	0.00	0.00	8.06	0.00	0.00	0.00	0.00	0.00	0.00
Internat	0.012		0.00	0.00	13.27	0.00	0.00	0.00	0.00	3.32	2.32	0.00

	Potential Improvement (kg/year reduction)									
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Western	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	0	0	0

Printing and Publishing

			Typical Raw Wastes (Kg/year)									
Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Texas	0.032	1	0.00	6.19	4.42	0.00	0.00	2.65	1.33	0.00	0.00	0.00
HydroGrap	0.146		2.22	1.82	3.84	0.00	0.00	2.22	0.00	35.73	0.00	0.00

	Potential Improvement (kg/year reduction)									
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Texas	0.00	5.70	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HydroGraph	0.00	1.82	3.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed	0.00	7.52	4.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Trinity River Authority
Grand Prarie, TX

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Battery

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
			Typical Raw Wastes (Kg/year)									
GNB	0.032	1	0.00	0.00	0.00	23.45	0.00	11.06	0.00	0.00	0.00	0.00

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
	Potential Improvement (kg/year reduction)									
Total Poll Removed	0.00	0.00	0.00	0.00	0.00	7.85	0.00	0.00	0.00	0.00

Plastics Molding and Forming

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
			Typical Raw Wastes (Kg/year)									
Americhem	0.019	1	0.05	0.21	0.79	0.26	0.00	0.00	0.00	1.92	0.00	0.00
Vinylex	0.03		0.00	0.00	0.00	0.00	0.00	0.00	0.00	149.32	0.00	0.00
Surgikos	0.3735	1	0	0	0	0	0	0	0	4440.971	0	0

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
	Potential Improvement (kg/year reduction)									
Americhem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00
Vinylex	0.00	0.00	0.00	)	0.00	0.00	0.00	92.58	0.00	0.00
Surgikos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2753.40	0.00	0.00
Total Poll Removed(kg/year)	0	0	0	0	0	0	0	2847.168	0	0

Trinity River Authority
Grand Prarie, TX

Company data supplied in mg/l. Converted to Kg/yr based on avg flow and a units factor: 1382.575

Electrical and Electronic Comp

Company	Avg flow (MGD)	In Compliance	Typical Raw Wastes (Kg/year) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Thermal	0.068	1	0.00	122.22	94.02	0.00	0.00	65.81	0.00	47.01	0.00	0.00
Electro	0.014	1	0.00	0.00	22.07	1.94	0.00	0.00	0.00	0.00	0.00	0.00
TRW	0.003		0.00	0.00	6.22	1.66	0.00	3.32	0.00	0.00	0.00	0.00
Boeing	0.0021		0.29	0.00	7.26	5.81	0.00	0.00	0.00	0.00	0.00	0.00
Hitachi	0.0018	1	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Irving	0.0077		0.53	1.28	159.69	11.71	0.00	6.17	0.00	1.38	0.53	0.00
A&L	0.0045		0.00	0.00	26.13	90.84	0.00	27.38	0.00	0.00	116.97	0.00
Circuitro	0.015		0.00	0.00	269.60	16.59	0.00	1.45	0.21	0.00	0.00	0.00
ElecDrill	0.0003		0.04	0.00	1.04	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Telcor	0.166	1	11.48	22.95	245.57	34.43	0.00	59.67	0.00	11.48	0.23	0.00
PMCircuit	0.01		0.69	3.46	71.89	40.65	0.00	0.00	0.00	0.00	0.69	0.00
NTexas	0.0445	1	0.00	0.00	278.71	7.63	0.00	1.29	0.00	0.00	0.00	0.00

Company	Potential Improvement (kg/year reduction) CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Thermal	0.00	20.78	22.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electro	0.00	0.00	5.30	0.77	0.00	0.00	0.00	0.00	0.00	0.00
TRW	0.00	0.00	1.49	1.64	0.00	0.00	0.00	0.00	0.00	0.00
Boeing	0.28	0.00	1.74	5.75	0.00	0.00	0.00	0.00	0.00	0.00
Hitachi	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Irving	0.51	1.14	38.33	11.59	0.00	0.00	0.00	1.37	0.00	0.00
A&L	0.00	0.00	6.27	89.93	0.00	0.00	0.00	0.00	0.00	0.00
Circuitron	0.00	0.00	64.70	16.42	0.00	0.00	0.00	0.00	0.00	0.00
ElecDrill	0.04	0.00	0.25	0.82	0.00	0.00	0.00	0.00	0.00	0.00
Telcor	3.44	3.90	58.94	13.77	0.00	0.00	0.00	0.00	0.00	0.00
PMCircuits	0.66	3.08	17.25	40.24	0.00	0.00	0.00	0.00	0.00	0.00
NTexas	0.00	0.00	66.89	3.05	0.00	0.00	0.00	0.00	0.00	0.00
Total Poll Removed(kg/year)	4.94	28.89	283.73	184.05	0.00	0.00	0.00	1.37	0.00	0.00

Grand Total	Avg flow (MGD)	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Pollutant Removed		202.31	7062.98	848.05	428.27	0.00	1529.86	77.38	3425.22	0.00	0.00
Ave Influent		0.01	0.055	0.078	0.04	0.0004	0.02		0.17		0.281
Total Plant Poll Loadings (kg/yr)	84	1161.36	7247.10	9058.64	4645.45	0.00	2322.73	0.00	19743.18	0.00	32634.32
Percent Removed		17.4	97.5	9.4	9.2	0.0	65.9	0.0	17.3	0.0	0.0

Westerly Treatment Plant
Northeast Ohio Regional Sewer District
Cleveland, OH
Assume Pretreatment

Company data supplied in mg/l. Converted
to Kg/yr based on avg flow and a units
factor: 1382.575
MCF-MGD: 0.000020

Inorganic Chemicals

	Avg flow	In	Typical Raw Wastes (Kg/year)								
Company	(MGD)	Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
(mg/l)			0.037	1.9	17	21	0.003	22	0.018	3	
AirProd	0.012	1	0.6	31.7	283.7	350.5	0.1	367.1	0.3	50.1	

	Potential		Potential Improvement (kg/year reduction)						
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
AirProd	0.0	30.4	85.1	301.4	0.0	154.2	0.1	34.0	

Electroplating and Metal Finishing

	Avg flow	In	Typical Raw Wastes (Kg/year)								
Company	(MGD)	Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
(mg/l)			0.283	27.46	12.63	0.331	0.001	15.47	0.023	12.47	1.856
Aircraft	0.007	1	2.59	251.30	115.59	3.03	0.01	141.58	0.21	114.12	16.99
AlumAnod	0.002	1	0.95	91.81	42.23	1.11	0.00	51.72	0.08	41.69	6.21
Arv	0.001	1	0.28	27.23	12.52	0.33	0.00	15.34	0.02	12.37	1.84
AutoTap	0.011	1	4.32	419.36	192.88	5.05	0.02	236.25	0.35	190.44	28.34
CTIndus	0.017	1	6.59	639.54	294.15	7.71	0.02	360.30	0.54	290.43	43.23
CleveMet	0.007	1	2.87	278.54	128.11	3.36	0.01	156.92	0.23	126.49	18.83
Duray	0.002	1	0.92	89.47	41.15	1.08	0.00	50.41	0.07	40.63	6.05
Guarantee	0.009	1	3.63	352.45	162.11	4.25	0.01	198.56	0.30	160.05	23.82
H and S	0.000	1	0.02	2.33	1.07	0.03	0.00	1.31	0.00	1.06	0.16
KBPlat	0.004	1	1.49	144.71	66.56	1.74	0.01	81.53	0.12	65.72	9.78
Kelly	0.077	1	30.24	2933.96	1349.45	35.37	0.11	1652.89	2.46	1332.36	198.30
Koster	0.001	1	0.55	53.68	24.69	0.65	0.00	30.24	0.04	24.38	3.63
Kyron	0.006	1	2.49	241.19	110.93	2.91	0.01	135.88	0.20	109.53	16.30
Master	0.001	1	0.54	52.13	23.98	0.63	0.00	29.37	0.04	23.67	3.52
Maynard	0.000	1	0.10	9.34	4.29	0.11	0.00	5.26	0.01	4.24	0.63
ProdFin	0.130	1	51.01	4949.85	2276.64	59.66	0.18	2788.57	4.15	2247.80	334.56
SRC	0.000	1	0.02	2.33	1.07	0.03	0.00	1.31	0.00	1.06	0.16
SouthShor	0.000	1	0.08	7.78	3.58	0.09	0.00	4.38	0.01	3.53	0.53
Strassen	0.002	1	0.87	84.81	39.01	1.02	0.00	47.78	0.07	38.51	5.73

Westerly Treatment Plant
Northeast Ohio Regional Sewer District
Cleveland, OH
Assume Pretreatment

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MCF-MGD: 0.000020

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
Aircraft	2.51	248.79	112.12	2.91	0.00	138.74	0.20	110.70	16.82
AlumAnod	0.92	90.89	40.96	1.06	0.00	50.69	0.07	40.44	6.14
Arv	0.27	26.96	12.15	0.32	0.00	15.03	0.02	12.00	1.82
AutoTap	4.19	415.17	187.09	4.85	0.00	231.53	0.33	184.72	28.06
CTIndus	6.39	633.15	285.33	7.40	0.00	353.09	0.51	281.71	42.79
CleveMet	2.78	275.75	124.27	3.22	0.00	153.78	0.22	122.69	18.64
Duray	0.89	88.58	39.92	1.04	0.00	49.40	0.07	39.41	5.99
Guaranteed	3.52	348.92	157.24	4.08	0.00	194.59	0.28	155.25	23.58
H and S	0.02	2.31	1.04	0.03	0.00	1.29	0.00	1.03	0.16
KBPlat	1.45	143.27	64.56	1.67	0.00	79.90	0.12	63.75	9.68
Kelly	29.33	2904.62	1308.97	33.95	0.00	1619.83	2.33	1292.39	196.32
Koster	0.54	53.15	23.95	0.62	0.00	29.64	0.04	23.65	3.59
Kyron	2.41	238.78	107.61	2.79	0.00	133.16	0.19	106.24	16.14
Master	0.52	51.61	23.26	0.60	0.00	28.78	0.04	22.96	3.49
Maynard	0.09	9.24	4.17	0.11	0.00	5.15	0.01	4.11	0.62
ProdFin	49.48	4900.35	2208.34	57.28	0.00	2732.80	3.94	2180.37	331.21
SRC	0.02	2.31	1.04	0.03	0.00	1.29	0.00	1.03	0.16
SouthShore	0.08	7.70	3.47	0.09	0.00	4.30	0.01	3.43	0.52
Strassen	0.85	83.96	37.84	0.98	0.00	46.82	0.07	37.36	5.67
Total Poll Removed(kg/year)	106.28	10525.51	4743.32	123.03	0.00	5869.81	8.46	4683.23	711.41

Iron and Steel Manufacturing

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN
(mg/l)			0	0	0	0	0	0	0	0.2	50
ForestCit	0.07	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	4499.33

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4499.33

Westerly Treatment Plant
Northeast Ohio Regional Sewer District
Cleveland, OH
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MCF-MGD: 0.000020

Aluminum Forming

	Avg flow	In	Typical Raw Wastes (Kg/year)									
Company	(MGD)	Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0	0	0.132	0.237	0	0.028	0	1.897	0	8.014
Arrow	0.007	1	0.00	0.00	1.36	2.44	0.00	0.29	0.00	19.51	0.00	82.42
HiStar	0.001	1	0.00	0.00	0.10	0.19	0.00	0.02	0.00	1.50	0.00	6.36

	Potential Improvement (kg/year reduction)									
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Arrow	0.00	0.00	0.00	0.80	0.00	0.00	0.00	6.24	0.00	0.00
HiStar	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.48	0.00	0.00
Total Poll Removed(kg/yr)	0	0	0	0.866436	0	0	0	6.724991	0	0

Printing and Publishing

	Avg flow	In	Typical Raw Wastes (Kg/year)									
Company	(MGD)	Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0	109	4.6	482	0	0.074	0	10.7	0.43	0
MetroPres	0.009	1	0.00	1300.19	54.87	5749.46	0.00	0.88	0.00	127.63	5.13	0.00
Schaefer	0.001	1	0.00	185.30	7.82	819.40	0.00	0.13	0.00	18.19	0.73	0.00
CentralLi	0.001	1	0.00	126.62	5.34	559.92	0.00	0.09	0.00	12.43	0.50	0.00
AmerCol	0.021	1	0.00	3218.04	135.81	14230.25	0.00	2.18	0.00	315.90	12.70	0.00
AmerGreet	0.045	1	0.00	6856.10	289.34	30317.80	0.00	4.65	0.00	673.03	27.05	0.00

	Potential Improvement (kg/year reduction)									
Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
MetroPress	0.00	1196.17	12.62	5519.48	0.00	0.00	0.00	122.53	0.00	0.00
Schaefer	0.00	170.48	1.80	786.62	0.00	0.00	0.00	17.46	0.00	0.00
CentralLith	0.00	116.49	1.23	537.53	0.00	0.00	0.00	11.93	0.00	0.00
AmerCol	0.00	2960.60	31.24	13661.04	0.00	0.00	0.00	303.26	0.00	0.00
AmerGreet	0.00	6307.61	66.55	29105.09	0.00	0.00	0.00	646.11	0.00	0.00
Total Poll Removed	0	10751.35	113.4317	49609.75	0	0	0	1101.295	0	0

Westerly Treatment Plant
Northeast Ohio Regional Sewer District
Cleveland, OH
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factor: 1382.575
MCF-MGD: 0.000020

Paint Formulating

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0.524	3.12	2.476	6.3	5.161	1.35	0.015	74.746	0.079	0.418
Cook	0.1021	1	73.98	440.50	349.57	889.47	728.66	190.60	2.12	10553.01	11.15	59.02
Schilling	0.0001	1	0.07	0.44	0.35	0.89	0.73	0.19	0.00	10.59	0.01	0.06

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Cook	73.98	440.50	349.57	889.47	728.66	190.60	2.12	10553.01	11.15	59.02
Schilling	0.07	0.44	0.35	0.89	0.73	0.19	0.00	10.59	0.01	0.06
Total Poll Removed(Kg/yr)	74.05517	440.9392	349.9248	890.358	729.3869	190.791	2.1199	10563.60	11.16480	59.07454

Textiles

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0	0.787	0.656	0	0	0	0	0.999	0.071	0.21
Lion	0.0115	1	0.00	12.55	10.46	0.00	0.00	0.00	0.00	15.94	1.13	3.35

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Total Poll Removed(Kg/yr)	0.00	5.02	4.19	0.00	0.00	0.00	0.00	6.21	1.13	3.18

Organic Chemicals

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0	0.228	4.78	1.95	0	0.339	0	1.36	0	1.27
Northeast	0.0018	1	0.00	0.57	11.92	4.86	0.00	0.85	0.00	3.39	0.00	3.17

Westerly Treatment Plant
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factor: 1382.575
MCF-MGD: 0.000020

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Total Poll Removed(Kg/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Plastics Molding and Forming

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0	0	0	0	0	0	0	0.598	0	0.098
Robin	0.0062	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	0.00	0.84
Cosmo	0.0036	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.95	0.00	0.48

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Robin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	0.00	0.76
Cosmo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	0.00	0.43
Total Poll Removed(Kg/yr)	0	0	0	0	0	0	0	5.01	0.00	1.19

Industrial Laundries

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0.059	0.56	1.67	5.1	0	0.18	0	3.2	0.13	0.65
Morgan	0.0305	1	2.49	23.61	70.41	215.02	0.00	7.59	0.00	134.91	5.48	27.40
Rentus	0.0007	1	0.06	0.57	1.70	5.20	0.00	0.18	0.00	3.26	0.13	0.66
West End	0.041047	1	3.35	31.78	94.78	289.43	0.00	10.22	0.00	181.61	7.38	36.89
Glove	0.010349	1	0.84	8.01	23.89	72.97	0.00	2.58	0.00	45.79	1.86	9.30
West Side	0.008074	1	0.66	6.25	18.64	56.93	0.00	2.01	0.00	35.72	1.45	7.26
Merchants	0.034182	1	2.79	26.47	78.92	241.03	0.00	8.51	0.00	151.23	6.14	30.72

Westerly Treatment Plant
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Assume Pretreatment

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MCF-MGD: 0.000020

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Morgan	0.42	20.54	54.21	210.72	0.00	0.00	0.00	125.47	0.00	0.00
Rentus	0.01	0.50	1.31	5.10	0.00	0.00	0.00	3.04	0.00	0.00
West End	0.57	27.65	72.98	283.64	0.00	0.00	0.00	168.89	0.00	0.00
Glove	0.14	6.97	18.40	71.51	0.00	0.00	0.00	42.58	0.00	0.00
West Side	0.11	5.44	14.35	55.79	0.00	0.00	0.00	33.22	0.00	0.00
Merchants	0.47	23.03	60.77	236.21	0.00	0.00	0.00	140.65	0.00	0.00
Total Poll Removed(Kg/yr)	1.73	84.12	222.03	862.97	0.00	0.00	0.00	513.85	0.00	0.00

Car Wash Subcategory

Typical Raw Wastes (Kg/year)

Company	Avg flow (MGD)	In Compliance	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
(mg/l)			0.043	0.099	0.54	2	0	0.15	0	1.5	0	0.54
Standard	0.0009	1	0.05	0.12	0.67	2.49	0.00	0.19	0.00	1.87	0.00	0.67
West Ohio	0.0007	1	0.04	0.09	0.50	1.87	0.00	0.14	0.00	1.40	0.00	0.50

Potential Improvement (kg/year reduction)

Company	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Standard	0.00	0.04	0.19	2.39	0.00	0.00	0.00	1.59	0.00	0.00
West Ohio	0.00	0.03	0.14	1.80	0.00	0.00	0.00	1.19	0.00	0.00
Total Poll Removed(Kg/yr)	0.00	0.06	0.33	4.19	0.00	0.00	0.00	2.78	0.00	0.00

lb-kg 0.454545	CD	CR	CU	PB	HG	NI	AG	ZN	CN	BEHP
Grand Total Poll Removed	182.07	21837.44	5518.33	51792.56	729.39	6214.80	10.66	16916.75	5223.04	63.45
Total Plant Loadings(kg/yr)	364.90	22900.8	6330.2	53938.2	NA	6588.0	11.3	17211.1	5298.8	NA
Percent Removed	49.9	95.4	87.2	96.0	ERR	94.3	94.2	98.3	98.6	ERR